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SMOKELESS POWDER—THE EXPLOSIVES OF THE PAST AND OF THE FUTURE.

THE science of explosives is now passing through one of the most curious phases of its history. The advent upon the world's stage of gunpowder, when it was discovered by Roger Bacon, in the thirteenth century, certainly did not give rise to clamors like those that are now rising around the new smokeless powder.

Since the nearly six centuries ago that war and the industries, each in its own domain, seized upon the antique ternary element of sulphur, saltpeter, and charcoal, the idea of smoke has been absolutely inseparable from that of the explosion of the mixture. A battle, as glorious as it may have been, in which the combatants were not enveloped in the legendary cloud of that smoke "which smells of powder and intoxicates man," would certainly, but a few months ago, have been comprehensible to no one.

The maneuvers recently performed at Champigny were, we believe, the first serious trials of a mock battle with the new powder. The astonishment, or stupefaction rather, manifested by the spectators was carried to the highest pitch. The plain and hills were covered with battalions, the crack of musketry discharge echoed amid the silence of the early morning hours, the detachments met nearly breast to breast, files of soldiers, knee to earth, fired their volleys by platoons of fifty or sixty men, and not a cloud, not a particle of smoke was visible. The army was clearly delineated upon the verdure of the sown fields, with the easily recognizable color of the uniforms, and the blinding, too blinding, brilliancy of the helmets and metallic ornaments. And, what was a still more astonishing phenomenon, it was not only the infantry whose light and elegant weapons discharged their light projectile without smoke, but also the heavy artillery, whose rapid and noisy detonation filled the air, without the accompaniment of an appreciable cloud. Nothing more than a whitish puff, quickly disappearing, indicated the location of the battery to the observer. It was therefore an unknown war—a war with elements absolutely different from those to which modern tactics are accustomed, that was inaugurated by the use of the new explosive, which has not as yet been experimented with upon a genuine battlefield, but which is already known under the name, to be hereafter celebrated, of "smokeless powder."

It may be rightly said that a new era has just opened for explosive substances. The history of powder, up to last year, is no longer, properly speaking, anything but archeology, at least as regards the powder used in war. In the new explosive with which our weapons—artillery as well as infantry—are now loaded, the antique formula has given way to an entirely original composition. No more saltpeter, no more sulphur, no more charcoal: the famous crucible of Berthelot Schwartz is upset for good. No more *black* powder, no more powder even, but a brownish composition made in the form of sheets or plates of horny aspect, which are afterward cut into small brilliant lamellæ. An entire revolution has taken place in the intimate composition of the explosive, as well as in its external form.

Such is the powder of the future, which no tie connects with the powder of the past, except the object in common to which both of them tend—the art of killing men as rapidly and as *dead* as possible. As regards this, our celebrated smokeless powder is not behindhand. Every one is now informed as to the magnificent result of the little ball of the Lebel gun, which traverses planks twelve inches in thickness and makes a hole through three soldiers in succession, and very delicately too, without its elegant trajectory in any wise deviating from its bloody course. The weapons of the past, the cartridges charged with the ancient black powder, did not perform such wonders! Let us confess, however, that this is not the moment for sentimentality. It will be time to think of that later on, when Victory shall again have sheltered us beneath her wings.

Although the most brilliant future can be predicted for the new arms and explosives, the powders of the past have likewise had their glorious pages, whether as regards their historic role in the wars of bygone ages or the scientific progress of which they have been the starting point. It has certainly required researches, experiments, and vigils in order to transform the rudimentary mixture mentioned by Marcus Græcus in his famous *Liber ignium ad comburendos hostes*, written between the ninth and thirteenth centuries, into the superb specimens of prismatic powders designed for loading those artillery pieces of large caliber which were last year exhibited on the Esplanade des Invalides, in the elegant pavilion annexed to the palace of the minister of war, by the superintendent of powders and saltpeter. Very curious specimens of these are represented in Fig. 3.

The manufacture of powders for war, hunting, and mining is too well known to allow us to describe it anew in detail in this place. The trituration of the prime materials — saltpeter, sulphur, and charcoal — the mixture and incorporation of the substances, pulverized in the requisite proportions, the caking of the said mixture, the graining of the cake, and the polishing, drying, and equalizing of the grains, constitute a series of operations which, in their very principles, are now no longer a secret to any one. In certain countries, where the manufacture of powder does not, as in France, constitute an exclusive monopoly of the state, there is no village that does not have a powder mill, however small, in its vicinity, that produces the sporting or mining powder necessary for the needs of the locality. The establishment sometimes (and often

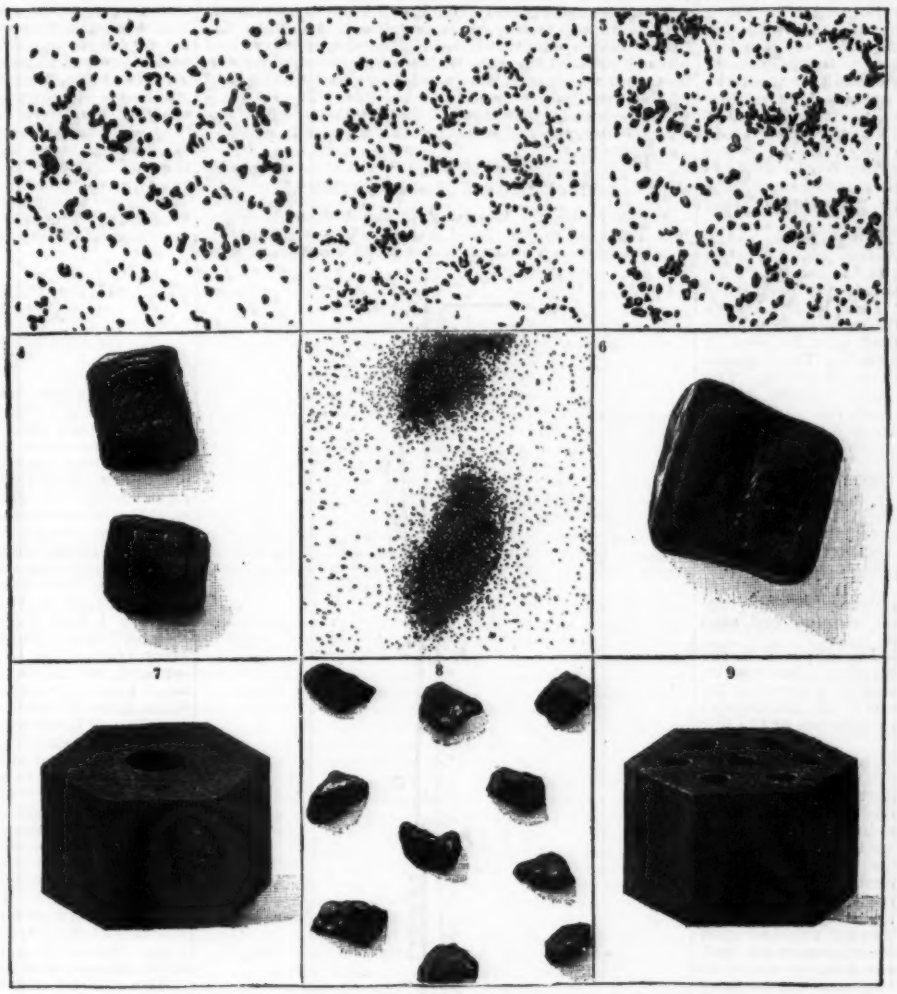


FIG. 3.—SPECIMENS OF VARIOUS POWDERS (ACTUAL SIZE).

1. French powder for Gras gun. 2. Powder for Russian gun. 3. Powder for Mauser gun. 4. Cubical powder. 5. Extra fine sporting powder. 6. Cubical powder for cannon. 7. Prismatic powder. 8. Small grained cannon powder. 9. Prismatic powder for cannon of large caliber.

FIG. 1.—MILL OF THE SEVRAN-LIVRY POWDER WORKS.

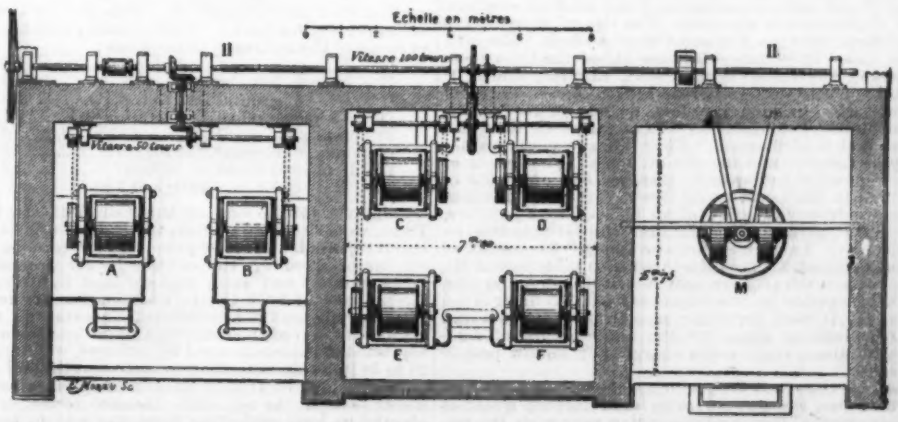


FIG. 2.—GENERAL ARRANGEMENT OF ONE OF THE MILL HOUSES OF THE SEVRAN-LIVRY POWDER WORKS.

M, Mills. C, D, E, F, Binary tuns. A, B, Ternary tuns. H, H, Shafting.

even) blows up, but the owner does not get discouraged for all that, and if he has been fortunate enough to be far distant from his pestles at the moment of the explosion, you will find him some fine day, with his shop all spick and span new, again triturating the ternary mixture with the most rudimentary apparatus, which, like their predecessors, are destined to blow up.

The national powder mills installed upon our territory and those in operation in foreign countries, and some of which are celebrated, . . . may be considered as the highest expression of the art of manufacturing black powder. In each of them, were we allowed to visit them one after the other, we should find the same installation and apparatus essentially the same, whose external arrangement, at least, we are acquainted with through the numerous reproductions of them that have been made in the treatises upon industrial chemistry that we have all had in our hands. There are three general processes, three methods, outside of the pulverization of the component materials: The pestle process, the mill process, and the "revolutionary" process, inaugurated in 1793 for the supply of the fourteen armies of the republic. It is this latter process that some of us saw in activity at the Phillipe-Auguste Powder Mill installed in seventeen days at Paris during the siege of 1870–71.

As an example of one of the most curious phases of the manufacture of powder, the only one that we shall recall here, we have selected and reproduce in Fig. 1 the mill process installed in our fine Sevran-Livry Powder Works by the inspector-general of powders and saltpeter, Mr. Maurouard, director to the minister of war. The mill process is, we think, that of the three processes now in use whose genealogy dates back farthest into bygone ages. It was already in use in the first half of the sixteenth century, in which the olive mill system of crushing caused it to be adopted. It was not till 1754 that our Essonnes Powder Works adopted it for the first time, upon the suggestion of a monk (a learned powder maker, it seems), the Rev. Father Ferry.

This point of history once established, let us examine our mills, after recalling that before being crushed under the heavy cast iron wheels, the substances composing the ternary explosive have already been triturated two by two by the binary tuns, in the known proportions. The two runners that we represent herewith are identical with those that may be seen in operation in all the French powder mills. Their diameter is about 5 feet and their thickness 19 inches. The horizontal table upon which they revolve is 6½ feet in diameter. The runners and the part of the table on which they roll are of hard cast iron of perfect homogeneousness. The weight of the rolling system varies according to the installation. The French runners just described weigh from 11,000 to 12,200 lb. On the contrary, the Dresden powder mill was, in 1871, still using 330 lb. runners. In order to prevent the powder from adhering to the runners, the exposure of the bed, and consequently the production of sparks that would cause an explosion, each runner is provided with a scraper. Besides, to the upper part of each apparatus is adapted a sprinkling device which in case of disaster at once inundates the circular bed, and, consequently, the room in danger.

The precautions just mentioned as adopted in the runner treatment of the ternary mixture, placed previously on the circular bed, are rigidly prescribed for each of the operations which concur in the finishing of the powder, ready for delivery to commerce or the war department.

A visit in detail to a powder mill, a simple inspection of a plan in relief would show us with what watchfulness and minute care the various departments for the preparation of the terrible explosive material are surrounded. As an example of the ingenious arrangement of the various houses that go to make up a complete powder factory, we show in Fig. 2 the general arrangement of the Sevran-Livry establishment. The legend beneath the engraving gives all the details necessary to make it understood.

Before the studies that are still being pursued upon the application of the new smokeless powder for loading large army and navy guns have entirely relegated our old black powder to the show cases of the Artillery Museum (those *Invalides* of military mechanics and chemistry), it is curious to recall the various external forms given the grains of powder manufactured in the different powder mills of the two worlds, according to the purposes for which the explosive is to be used. In Fig. 3 are reproduced the most curious specimens exhibited in the show case of the exposition of powders and saltpeter—powders of war (in the center of which there is shown a sporting powder for the sake of comparison) designed for both infantry and artillery uses.

Here we have in the first place an infantry powder in grains, the F powder (F being the initial letter of *fusil*, the French term for gun) and especially for the Gras gun, of the 1874 model (Fig. 3, No. 1). Its proportions are (we might say were, since this powder is now entirely replaced by the smokeless powder of the Lebel gun) 77 per cent. of saltpeter, 8 per cent. of sulphur, and 15 per cent. of charcoal. The size of the grain is comprised between 0·03 and 0·06 of an inch. Beneath (Nos. 4 and 6) we have what are called the C powders (C being the initial of the word cannon), and S P (initials of the words siege and place), dense, hard and very coarse grained powders, as our figure shows. Their uniform composition is 75 of saltpeter, 10 of sulphur, and 15 of charcoal. They differ from each other only in density and the size of grain. The grains of the C powder, for example, measure 0·25 and 0·275 of an inch in diameter, while those of the S P powders measure from 0·35 to 0·5 of an inch. These powders, C and S P, permit of giving great initial velocities to projectiles. Let us mention also the M C 30 powder, so called because it is manufactured with mills (initial M), is a cannon (C) powder, and is triturated for 30 minutes. Its grains have a diameter from 0·05 to 0·1 of an inch. It is used for firing smooth-bore mortars and muzzle-loading guns, for the manufacture of compressed disks, and for the charging of hollow projectiles.

Besides these powders, which were but yesterday in current use, the powder mills manufacture qualities whose external form and dimension vary with the mechanical work they are to perform. Certain of these powder grains, cubical and hexagonal, have a side measurement (such as the Italian "dice" powder) of from 0·4 to 0·45 of an inch. Some prismatic grains manufactured in America vary from 1 to 2 inches; a "pebbled" powder, manufactured at Waltham Abbey, measures 1·4 inch; a hexagonal powder containing six apertures measures 1·5 inch in width by one inch in thickness (No. 9). The Hamm powder mill is manufacturing 12 inch perforated grains, and Wetteren, in Belgium, is manufacturing remarkable powders that are from 1 to 1¼ inch in thickness. The American mills go still further, and we have seen specimens whose hexagonal grains measured 3 inches at the base and were 2¾ inches in thickness. It is scarcely necessary to point out that the object of these powders of large caliber is to reduce the speed of ignition of the grain itself—say to obtain a slow powder giving the projectile a great initial velocity.

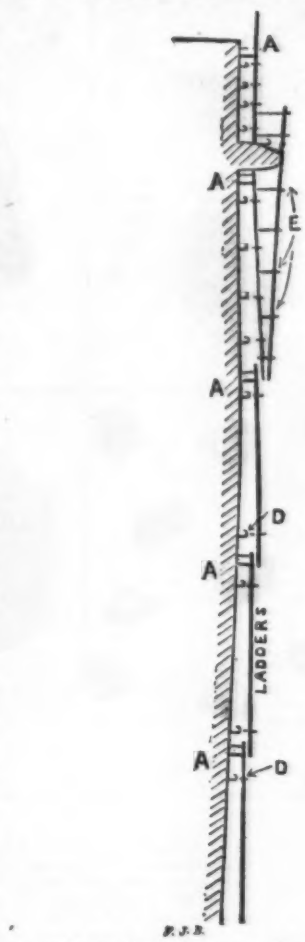
But here we have already devoted much space to our old, and now abandoned, black powder. The service that it has rendered us in the industries and the victories or defeats that it has enveloped with its glorious smoke will leave an ineffaceable mark in the history of peace and war. For a long time yet, in the narratives of historians, and upon the celebrated canvases of our museums, the generations that are to succeed us will feel themselves stirred up at the simple account or upon an examination of the battles over which, torn by balls and blackened by smoke, wave the flags of regiments bathed in blood. The artists who are to depict the great battles of the future, and the writers who are fix the events of them, will have to leave aside this powerful means of impression. Adieu to the heroic cloud, which, in the fourteenth century, had already covered the combatants of Crecy with its shadow, and which served as a winding sheet to the dead of Reichshoffen; its record is finished. The future is to contests in the midday sun, to battles in which the new powder, the smokeless powder alone will speak.—*La Nature.*

LADDERING A TALL CHIMNEY.

FIFTY years ago Messrs. P. Dixon & Sons, of Shaddon Works, Carlisle, built a tall octagonal chimney shaft, which is a landmark for miles around, in connection with their cotton mill. This shaft is described in Bancroft's treatise on "Tall Chimney Construction" as being of the following dimensions:

	Ft.	In.
Height from foundation to top.....	330	6
" " ground line to top.....	300	0
Outside measurement at ground line....	17	4
Inside measurement at ground line.....	9	6
Outside measurement at top	9	0
Inside measurement at top.....	6	8

Built to a batter of 1 in 72.



A, skids, or distance pieces; D —, 9 in. iron dogs or holdfasts; E, rope lashings.

Being the jubilee year of this tall shaft, Mr. Robert Todd, woolen manufacturer, the present occupier, has had it repaired, and a new patent copper rope lightning conductor fixed up the outside by Mr. Joseph Ball, large chimney and spire restorer and lightning conductor fixer, of York Castle, Oldham, Lancashire.

In carrying out this important undertaking, the ascent to the top of the shaft was made by fifteen ordinary wooden ladders as used by painters, weighing from 20 to 30 lb. each, according to their length, and of the average width of 11½ in. at bottom and tapering to about 10 in. at the top, with distance pieces, or skids, about 8 in. long projecting from one side to keep the ladders from the brickwork, thus providing a secure foot and hand hold for the workmen. The first length or section of ladder was placed at the base of the chimney shaft, and a hooked wrought iron dog or holdfast made from ¾ in. round iron, about 9 in. long, driven firmly into the brickwork four feet up from the bottom of the ladder, and a second iron holdfast four feet down from its top. The dogs, or holdfasts, are so formed, as will be seen from the sketch, that they can be driven into the joints of brickwork and the ladders lashed to them.

Having fixed the first length, a free ladder is placed against it, which the workman climbs until he can reach about four feet above the fixed length, and drives into the brickwork a dog, and attaches a pulley and block to the same, and one end of the rope reeved into the pulley block is brought half way down a second loose section of the ladder placed by the side of the first. The rope is there fastened, and the second length is hauled up by workmen at the base of the shaft until it is half its height above section No. 1. It is then temporarily lashed to the first length, and the steeple jack climbs up it and drives another iron holdfast into the brickwork four feet above its top.

He then shifts the pulley block to upper holdfast and descends. Length No. 2, still attached to the rope at its middle, is then hoisted up to its full height above the first length fixed. The climber then ascends up the rungs of length No. 2, which is still held by the pulley block and rope, and drives in a holdfast near the bottom, and another near to the top, thus firmly holding its rungs to the brickwork of chimney, and so the second length forms a continuation of the first one fixed. The workman is then able to mount to the top of the second length and drive in another holdfast about one foot higher, and again with pulley block and rope haul up section No. 3, and so on until the cap is reached, and here a difficulty presented itself. In Messrs. Dixon's shaft, at about ten feet from the top, a stone cornice projects 3 ft., and the ladder inclining outward (see sketch) had to be lashed to the one fixed close under the cap. When climbing this the workman's back was toward the ground. The top of slanting ladder was also lashed to the bottom of the ladder fixed above the stone cap. The operation of laddering the chimney occupied five hours from the commencement.

THE SHIP'S CHRONOMETER: ITS HISTORY AND DEVELOPMENT.*

By HENRY DENT GARDNER, F.R.G.S.

Historical.

IN tracing the history of the ship's chronometer, it will make our subject more interesting if we will endeavor, for one brief moment, to put ourselves in touch with the era which preceded its existence. The early explorers had completed their great voyages and geographical expeditions, and had sketched out for us in rude outline the greater portion of the map of the world which we have to-day; but the difficulties of navigation were enormous. With the obscurity which attended the determination of the longitudinal positions of their ships, it is hardly a figure of speech to say that navigators must have groped their way from sea to sea. In a typical atlas of the middle of the seventeenth century I find the longitude of such places as the "Cape," Cape Horn, Cape Race, Cape Comorin, in error from 6° to 12°, and if such was the confusion on land, we may be sure it was very much greater at sea. I am informed that it was no unusual thing for ships, after securing as nearly as possible their proper parallels of latitude, to go sailing on, haphazard, until they should stumble, so to speak, upon the shores at which they were aiming. In order that I may make the subject clear to all, let me speak for one minute of the method by which longitude is determined. To ascertain your longitude you must know the local time of two different places; you must know the local time (the what o'clock it is) of the place where you are; and you must know the local time (the what o'clock it is) of the place from which you started, or from which you wish to measure. The difference between these two "times" will give you your longitude, east or west, at the rate of one degree of arc for every four minutes of time. So now it is evident how the question of longitude connects itself with the ship's chronometer.

Toward the end of the 17th century men's minds were getting very busy with this question of how to determine the longitude at sea. There was not so much difficulty in finding the local time of the ship's position—the perplexing point was how to get at the corresponding local time of the place from which the vessel had started. Such watches as existed in those days were totally inadequate to carry the time with sufficient accuracy; they would lose or gain at the rate of one minute a day for every 10 deg. rise or fall in temperature, and would not continue going while being wound. Indeed, the idea of obtaining a portable time keeper of sufficient accuracy was at first derided. On the other hand, astronomical methods such as could be used at sea were equally imperfect; there were no proper lunar tables, no reflecting quadrants, and Greenwich Observatory itself had only just been founded. Endeavors were made to make use of pendulum clocks at sea, and I may mention that their great advantage (if they could have been employed) would have been in the fact that they would have been affected by changes of temperature in comparison with a watch only to the extent of one-fifteenth.

Rewards for means of determining the longitude at sea had been previously offered by the Spanish and Dutch governments; but in 1714, so urgent had the question grown, the British government offered a reward of 20,000*l.* to any one who could find means of discovering the longitude at sea to within half a degree. By the act of Parliament a Board of Longitude was created, and this board had power to assist inventors and give smaller awards of 15,000*l.* and 10,000*l.* for methods of determining the longitude to within two-thirds of or one whole degree. The offers of such large sums of money naturally stimulated both astronomers and clock makers, but no discovery of anywhere near sufficient accuracy ensued until the year 1735, when a certain John Harrison, a native of Yorkshire, and the son of a carpenter, made his appearance in London with a time keeper which he had invented and constructed.

In a paper read long afterward before the Royal

* A paper recently read before the Royal United Services Institution. The paper was illustrated by models and instruments kindly lent for the occasion by the Science and Art Department, the British Horological Institute, and Mr. Thomas Buckney, F.R.A.S.

Society, there is a most interesting account of his interviews on that occasion with Dr. Halley, the celebrated astronomer, and Graham—whose invention, the astronomical clock, still maintains its position with but slight alteration in every observatory in the world. Although they were both competitors with Harrison for the great government reward, they afforded him every assistance, and it was owing to their certificates that he was permitted to proceed with his time keeper in a king's ship to Lisbon, where it is stated that he was able to determine the longitude to within 1° 30'. Upon this success, Harrison received the assistance of the Board of Longitude to the extent of 500*l.* to enable him to proceed with his experiments. For a prolonged period he continued his researches, and constructed a second and a third time keeper. His third time keeper was an entirely new departure, his former ones having been made more upon the model of clocks than watches. Harrison's third time keeper, which, with his previous ones, is deposited in Greenwich Observatory, resembles in most respects that very interesting instrument made by his apprentice, and used by Captain Cook, which is the property of this institution. Harrison's third time keeper was dispatched upon a trial voyage to Jamaica in 1761. On its arrival there it was found to be in error but 5·1 seconds, and on its return to Portsmouth, in 1762, its complete variation for the whole voyage amounted but to 1 minute 54·5 seconds. Upon this result Harrison claimed the reward; but he did not get it until three years afterward—after another voyage and further trials. We have, fortunately, a day to day record of the performance of this historical chronometer at the Royal Observatory, which I have, in order to

1766.	Seconds.	Mean temperature.	1766.	Seconds.	Mean temperature.
July 16.....	+133·2	63°	November 19	+131·6	48°
„ 23.....	+137·2	63	„ 26	+126·3	50
„ 30.....	+136·3	60	December 3	+112·6	43
August 6...	+126·6	63	„ 10	+111·0	40
„ 13...	+ 88·4	64	„ 17	+123·3	43
„ 20...	+ 70·9	61	„ 24	+ 96·6	38
„ 27...	+ 50·1	64	„ 31	+ 54·4	37
September 3	+ 82·9	63	1767.		
„ 10	+ 91·8	59			
„ 17	+ 81·3	57	January 7..	+ 6·3	34
„ 24	+ 86·1	62	„ 14..	+ 21·8	30
October 1 ..	+ 80·6	58	„ 21..	+ 39·3	31
„ 8 ..	+ 81·1	58	„ 28..	+ 72·1	38
„ 15 ..	+ 95·1	49	February 4	+107·6	46
„ 22 ..	+121·7	50	„ 11	+110·8	43
„ 29 ..	+140·5	52	„ 18	+118·1	45
November 5	+141·1	50	„ 25	+117·4	44
„ 12	+124·3	44	March 3....	+127·3	45

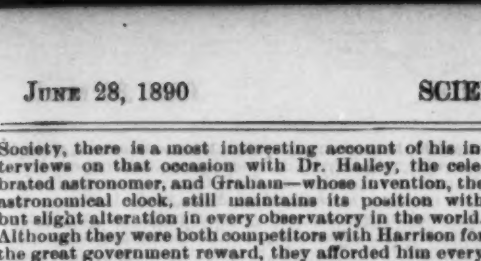
+ signifies gaining.

facilitate comparison with modern instruments, reduced to the present method of weekly sums of daily rates.

Descriptive—Historical.

It must now be my endeavor to explain a little of the technical construction of the ship's chronometer, and to speak of the properties and conditions upon which its time-keeping qualities depend. First of all, there is a mainspring, and like all other springs, the further it is wound, the harder it pulls. You cannot see the spring (Fig. 1) because it is contained in the barrel, BB.

FIG. 1.



A chain, C, connects BB with the contrivance, AA, which is called a fusee. The function of the fusee is to equalize the power of the mainspring, for when the mainspring is wound furthest it acts upon the thinnest part of the fusee—that is, on a lever of shorter radius; and when nearly down on the thicker portions of the fusee—that is on a lever of longer radius. Riding upon the arbor of the fusee is the great or first wheel of a succession or "train" of wheels. The object of this train is to convert the strong pull of the mainspring, acting for a few turns, into feeble force at the escapement, acting for many turns. Thus the last wheel in the train of a two-day chronometer generally goes round about 3,000 times against a single turn made by the great wheel, and, were it of the same diameter, would press against the escapement with $\frac{1}{3000}$ part of its force.

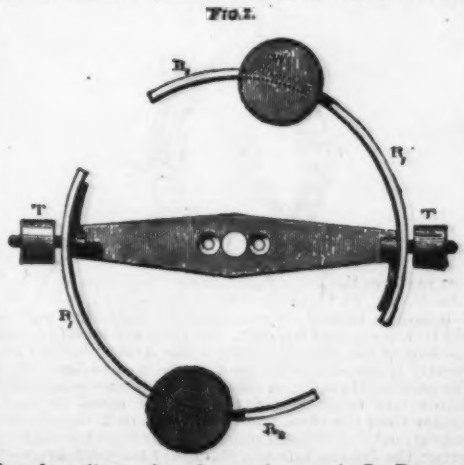
The escapement is that portion of the mechanism which converts the continuous motion of the wheels into the reciprocating motion of the balance. The vibratory motion of the balance is maintained by a spring against which it is thrown at each beat of the escapement. It is this spring which generally shows so conspicuously in every watch and chronometer. On account of its remarkable property, this spring is often called the pendulum spring, for, like the cycloidal pendulum, it possesses, when truly adjusted, the quality of isochronism—that is, it is able to compel the balance to perform long or short arcs of vibration in equal times. This quality is a mathematical consequence of the fact that the further the spring is deflected, in direct proportion, so much the harder it will push. Dr. Hooke, who discovered this fact, gives it in the form "Ut tensio sic vis," a statement which he concealed in the form of an anagram for some years. It is upon this quality that the time-keeping capacity of all watches and chronometers in the first instance depend. Until the time of Harrison, however, this spring was practically useless for all or any purpose of accurate time keeping, by reason of its being so greatly affected by change of temperature.

If the experiment were tried, it would be found that an uncompensated time keeper if adjusted to go right at a temperature of 32° would lose six minutes twenty-five seconds a day at a temperature of 100°. It was Harrison who was the first to correct this error. Knowing that brass expanded more than steel, he took an equal strip of each metal, and fastened them securely together side by side. The result which followed was this: with an increase of temperature his strip of compound metal bent over on the side toward the steel, and with a decrease of temperature his compound strip bent over on the side of the brass.

Thus he got motion following upon a change of temperature, and he applied it to the pendulum spring, just upon the same principle as is used in ordinary regulation. Every one knows that to make a watch go fast or slow the regulator must be shifted, and Harrison's "compensation curb" was an automatic regulator following change of temperature. Harrison's other inventions consisted of the "going fusee," which enabled the time keeper to keep going while being wound; he also used a train *remontoire* which intercepted variations in the friction of the train of wheels from reaching the escapement, and he employed a novel form of escapement in which the action was more direct, and the arc of vibration was more extended. When Harrison invented his compensation curb he did not know where to put his regulator, for if he had put the regulator in front of the curb, the curb would have been useless, and if behind the curb the regulator would have been useless. So he did without one, and this accounts for the wide daily rate of his chronometer from mean time. It is curious how the same thing seems to have puzzled Mudge, Cumming, and Berthond. Thus, Mudge had two pendulum springs, one for the regulator to act on, and one for the curb to act on. In Cumming's chronometer, the compensation existed in applying an open ring of brass to the interior of a closed ring of steel, and the brass expanding more than the steel, lateral motion between the rings ensued upon a change of temperature. And Cumming having fixed his pendulum spring to the end of a lever worked by the expansion of the brass ring, it was so pushed or pulled through the curb pins. Berthond used an apparatus similar to the gridiron pendulum in clocks for obtaining motion upon a change of temperature; but he had not only two pendulum springs, but two balances geared together, one pendulum spring being attached to one, and one to the other. The idea of having two balances geared together originated, I believe, with Dr. Hooke, and its object was to prevent the turning of a ship affecting the going of the chronometer. For if two balances are geared together, you have one moving the one way and one the other, and any circular motion which would accelerate one would retard another, and the mutual effects would cancel. We recognize in these days such arrangements to be illusory and mischievous, for our modern balances turn so fast (at the rate of about 1,800° in a second) that there is no time for the ship's motion to take effect. Harrison's chronometer had no gimbals, as he considered them (a notion very much opposed to ours) detrimental. On the other hand, he desired that the position of his time keeper should be shifted in its box, so as to counteract the "lie down" of the ship, and this as often as the ship changed her tack. I may remark, however, that it is very necessary that a ship's chronometer should hang steady in its gimbaling; sometimes a slight tremor may be noticed following each vibration of the balance, and this is highly prejudicial.

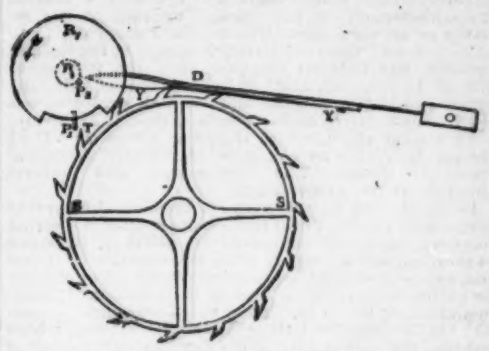
It was a Frenchman, Le Roy, who made the first great advance upon Harrison's chronometer. Le Roy dispensed with anything in the form of a compensation curb, and adapted the compensation to the balance. After all, the balance is only a kind of fly-wheel, and according as the weights upon it are put nearer to or further from its center, so it will gain or lose. Le Roy applied a mercurial thermometer to the balance, the bulbs being outside and the stems turning inward, so that when there was a rise of temperature the mercury moved toward the center, reducing the moment of inertia, and so counteracting the loss of elasticity of the pendulum spring. This was a great improvement, because the pendulum spring, in which the time-keeping property of the chronometer resides, was not interfered with. In these days, no one would think of doing anything to disturb the pendulum spring, and when a chronometer requires regulation, there are some little screws upon the balance which are turned inward or outward. Mudge, who followed Harrison in England, still continued to use the compensation curb, and, I think, made no great advance, although he got 3,000 *l.* from the Board of Longitude. His principal work was to adapt the *remontoire* to the escapement. It is true this invention may have led the way to the use of the gravity escapement in turret clocks, but it turned out of no service to the marine chronometer. The next great inventor and improver of the marine chronometer to follow Harrison was Arnold. Arnold (unless we are to believe certain

FIG. 2.



French writers, who give preference to Le Roy and Berthond) entirely remodeled the fabric of the chronometer, and, in any case, there is no doubt that his patents of 1776 and 1782 are conspicuous steps in advance. Arnold, instead of using a thermometer like Le Roy, applied Harrison's method of joining brass and steel to obtain a bending movement upon the rim of the balance. In Fig. 2 is shown the principle adopted. R_1, R_2, the rims of the balance, are steel inside and brass outside, the steel and brass being firmly united. Upon a rise or fall of temperature, the rims will therefore bend either inward or outward, carrying the weights, WW, with them, and compensating by the change of inertia for the loss or gain in the elasticity of the balance spring. By shifting the weights forward or backward along the rim, the action of the compensation is increased or diminished. The screws, TT, are for altering the time of the chronometer, as already intimated. Arnold also altered the form of the pendulum spring; hitherto it had been shaped as a flat spiral, but Arnold put it into the form of a cylindrical helix with incurvating ends, "rendering all the vibrations of equal duration, because the figure is always similar to itself." Lastly, Arnold produced the celebrated detached escapement (see Fig. 3). SS is the

FIG. 3.



escape wheel, which is now being held by the detent, D. R_1R_2 are two rollers, the smaller being situated in the plane of the detent and the larger in the plane of the escape wheel; both are on the same spindle as the balance. The balance is now turning in the direction of the arrow; by and by, the finger, P_2, upon the small roller, will come round and lift away the detent, and the wheel will be free. The tooth, T, will then drop upon the impulse pallet, P_1, and deliver impulse to the balance. Meanwhile, the finger, P_2, gets clear of the detent, which it allows to fall just in time to receive the succeeding tooth of the escape wheel. The balance now passes on to the limit of its excursion and returns, but in returning the finger does not interfere with the detent, for the detent, D, is actually too short to reach it. Just now, the finger really unlocked the detent by means of the little spring, YY, which is fastened some distance down the detent, the little spring being supported by the horn or extremity of the detent; but when the finger returns, it merely lifts out the spring, as there is upon this side no horn or extremity to support it. Both the balance shown in Fig. 2 and the escapement shown in Fig. 3 would be technically described as Earnshaw's, because they are in the form in which they were left by Earnshaw. Earnshaw's balance differs from Arnold's in respect of the method of making, and Earnshaw's escape wheel has a differently formed tooth to Arnold's. In Arnold's wheel, the tooth had the figure of an epicycloid, which got worn in practice. Earnshaw was a chronometer maker of high mechanical ability, and he carried the improvement of the chronometer so far that, after his time, the government offered no more great rewards. It is proper to mention that Arnold's inventions were rewarded with the sum of 3,000 *l.* from the Board of Longitude.

Descriptive—Modern.

As I am now approaching to within measurable distance of our own times, I will no longer pursue the historical method which has been adopted hitherto, but, taking the marine chronometer as I find it to-day, will endeavor to describe to you its perfection and imperfection, and what are now the best methods adopted of testing and rating it. Marine chronometers are made to go for eight days or two days. The two day instruments, unless for some very particular reason, are to be preferred, as they have higher numbered center pinions, and they admit of larger and heavier balances. Moreover, the two day chronometer should be wound every day. If you open a two day chronometer, the most conspicuous part of it will be the balance and pendulum spring, the wheel work and escapement being hidden between the frames. The brass frames are not gilded as watch frames are; they are better "spotted" and polished, because gilding softens the metal a little. The holes in which the pivots of the balance and the escape wheel play are jeweled. The lower seconds wheel pivot hole is jeweled, as is also sometimes the upper. The holes in which the pivots of the center wheel, fusee, and barrel arbor play are generally left in brass, the friction of a brass hole being somewhat smaller where the pressure is great. The mainspring is inclosed in its box, and cannot be seen, but it should have been hardened and tempered, and well polished, and great care should have been taken to avoid anything like "grinding." The fusee adjustment should also have been carefully tested, to ascertain that the pull of the mainspring (increasing as it is wound up) was properly balanced by the decrease in the diameter of the fusee. The gearing of the wheels should have been run with great care. The numbers of the teeth in the wheels and pinions are usually as follows: Great wheel, 90; center pinion, 14; center wheel, 90; third pinion, 12; third wheel, 80; fourth pinion, 10; fourth wheel, 80; escape pinion, 10; escape wheel, 15. If I start the balance of a chronometer, and watch the "getting up" of its vibration, I shall see that it will gradually reach to an arc of about 225° on each side of the position it started from, which we will call zero. This means that the complete swing of the balance will be about 450°, which would be technically called 1¼ turns. The complete vibration should be not less than 400° or over 500°. The angle of impulse does not much exceed 40°, and, as you remember, the wheel only gives impulse at every other vibration of the balance (see Fig. 3). If we add twice five degrees, which is about the angle of engagement of the little finger, P_2, with the spring, YY, during each vibration, we shall find that during two complete vibrations, amounting in all to about 900°, the

balance is only in connection with the escapement for about 50°, and swings for the remaining 850° free and undisturbed. There is no other escapement so detached as this is, and, moreover, the impulse being so direct, it needs no oil, which is an unspeakable advantage. It is sometimes curious to find, after several years of going, that the hard jewel impulse pallet, P, has been worn away and pitted by the action of the brass escape wheel, which remains itself unimpaired, while the gold passing spring, YY, which has probably been lifted some 300 million times during the same period, is but slightly marked. Although the balance is so little under the action of the escapement, it must not be forgotten that it has the varying friction of its own pivots to disturb it. Changes of barometric pressure can have but little effect upon the going of chronometers; indeed, if the isochronism be good, within ordinary limits the effect must be unperceivable. Some years ago I placed a marine chronometer under the partial vacuum of the receiver of an air pump. The pressure was from 13 to 21 inches, and the trial lasted 7 days. At the normal pressure the balance vibrated 440°, but it rose to 472° at 15·5 inches, and 495° at 13 inches. On the other hand, the rate of the normal pressure was —0·3 second daily, and its rate within the vacuum +0·2 second daily, which shows a difference of 0·5 second daily, due to a change of pressure averaging about 12 inches. The temperature was uniform throughout the experiment.

In the making and adjusting of the pendulum spring the utmost care and skill is requisite. After the spring has been hardened, tempered, and polished, it is put in position, and a series of trials are conducted. These trials are sometimes somewhat laborious. The chronometer has in the first instance to be got tolerably near, in and out of the oven. Then the isochronism is tested; this is done by letting down the ratchet, which reduces the power of the mainspring, and the arc of vibration in consequence is lowered. If the isochronism is found to be imperfect, the chronometer must again be tested in the oven, because in the oven the vibration is always increased by the action of the heat upon the oil, and errors of temperature and isochronism are mixed up. This process is repeated until compensation and isochronism are found to be correct. It is tolerably well understood that isochronism within certain limits as to length depends upon the form of the spring. But how complicated the question is has been well shown by an experiment of Mr. Kullberg's. Having isochronized a chronometer with an ordinary non-expansion balance, he replaced the balance by one with cut rims, as shown in Fig. 2. On again testing the isochronism, he found it from 12 to 14 seconds a day fast in the short vibrations, and he attributes this difference only to the increased pull of the centrifugal force upon the cut rims of the second balance. There is a singular error which exists at first in many chronometers, a tendency to accelerate or gain upon their rates. Mr. Kullberg attributes this to a want of homogeneity due to tempering, one side of the spring being in tension, and the spring as a whole, therefore, weaker. As a consequence of the spring being always in vibration, he considers that homogeneity is in time restored, and so the spring gets stronger. It is desirable that chronometers should be left some 2 seconds a day fast in the short vibrations, because in the natural course the vibration falls off through the thickening of the oil, and the excess of gain in the short vibrations will about compensate for that independent retardation which is due to it. If a chronometer keeps regularly losing upon its rate, it is very probable that the pendulum spring is rusting, and losing its force in consequence. All springs intended for the Admiralty are now left white, as it is found that white springs are less attacked by rust.

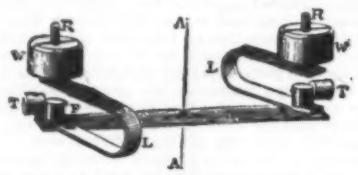
In a paper read before the British Association in 1834, the author (the late E. J. Dent) gave some very interesting particulars respecting springs of different materials which he had been experimenting with. He found that while a chronometer with a glass disk for a balance and a spring of steel would lose 6 minutes 25 seconds upon a rise of temperature of from 32° to 100°, under the same conditions a gold spring would give a loss of 8 minutes 4 seconds, a spring of palladium 2 minutes 31 seconds, and a spring of glass a loss only of 40 seconds. The chronometer with the glass spring excited some curiosity at the time, and provision being made for its compensation, it was tried at the Royal Observatory for a period of nine months. As I believe it to be the only instance of a glass spring ever having been applied to a chronometer, its mean daily rate while there may be of interest. 1833: November, + 0·6 second; December, + 2·0 seconds. 1834: January, + 2·2 seconds; February, 2·0 seconds; March, 1·9 seconds; April, 2·7 seconds; May, 2·7 seconds; June, 3·3 seconds; July, 4·0 seconds. Palladium springs, after being neglected for so many years, are now again coming into use.

If you open a chronometer which has attained a high position on the Greenwich list, you will probably find that it has a balance of very different appearance to that shown in Fig. 2. As chronometers became more perfect, and the ranges of temperature to which they were exposed became more extended, a curious error began to show itself. It was found that a chronometer which was timed to go right at temperatures of 90° and 60° would, if subjected to a temperature of 32°, lose some 4 or 5 seconds a day. This error, which is called the secondary error, is chiefly to be ascribed to the fact that the moment of inertia of the balance varies, not as the distance, but as the square of the distance of the weights from the center. Suppose the compensation weights to move over equal increments of radial space for equal increments of temperature, and let us assume the radius of the balance at a temperature of 90° to be unity, and at 60°, $1 + x$, and at 30°, $1 + 2x$. Then the moment of inertia of the balance (that is to say, its controlling power as to time upon the spring) at the three temperatures, 90°, 60°, 30°, will be proportional to the squares of the above, viz., $1 + 2x + x^2$, and $1 + 4x + 4x^2$. But if we grant (as must be nearly the case) that the elasticity of the balance spring varies with the temperature, then the above expressions ought to be in arithmetical progression, which we see they are not, for the last of them is too big by $2x^2$; that is to say, the moment of inertia in the cold is too great, and the chronometer will go slow, as I told you.

Moreover, if you will give the subject a little thought, you will see that this error of losing in the cold may be varied in two different ways. For, if the chronometer be going slow in the cold, you can put the compensation weight back on the rim of the balance until it goes right. But by doing this, as it was right in the heat before the weight was removed, you will cause the chronometer to lose precisely as much in the heat as it did in the cold. Or, a third course would be to put back the weight half the necessary distance, and then the error will be divided one-half in the heat and one-half in the cold. What is really wanted to correct the error is a balance that shall move faster inward than it does outward, or, at any rate, shall move more weight inward than outward. There seems to have been no successful attempts toward such a balance until the year 1840. In that year Molyneux took out a patent for a balance, the same in principle as Fig. 2, but having a little carrier inside the rim. In the heat, when the rim moved inward, it picked up the carrier and took it along with it, but when the rim moved outward it left the carrier behind, thus more work was done (from mean temperature) for an increase of heat than for an increase of cold. When Molyneux announced his patent, it turned out curiously enough that a certain chronometer maker, named Eiffe, had had under trial at Greenwich a chronometer with a precisely similar balance. As Molyneux had secured the patent, the government, at the recommendation of the astronomer royal, rewarded Eiffe with the sum of £300. The obvious objection, in theory, that this arrangement is discontinuous in its action, does not seem to be supported in practice, and it is the father of many modifications.

The first continuous secondary compensation balance was Dent's, patented in 1842, and this consisted of a flat bar, composed of steel above and brass below, with two loops or staples mounted upon it for the secondary compensation (see Fig. 4).*

FIG. 4.



The function of the main bar FB was to accomplish the primary compensation, by tilting the weights WW to or away from the center, after the manner of one of Arnold's in 1821. The secondary compensation was effected by the two loops, LL, which were also composed of brass and steel united; and in the heat, these raised the compensation weights, so that they advanced more rapidly toward the center, and in the cold they depressed the weights, so that they moved more slowly from the center. Thus the action of the main compensation was increased in the heat and diminished in the cold. In this way the secondary compensation was accomplished.

Another form of continuous balance (see Fig. 5) was

FIG. 5.

patented by Loseby in 1852. In this, thermometer tubes were fitted to the ordinary form of balance, and the tubes were so curved that in the heat the mercury tended to approach the center with greater and greater rapidity.

Another principle of secondary compensation is that adopted by Poole, and in this case the action of the rim outward is checked by a screw, and in Fig. 6 is seen a modern adaptation of this principle by Kullberg. In Hartnup's balance the central "Arnold" bar is inverted, and there are two other compound bars to increase the secondary action upon the rim, the latter being beveled to an angle of 45°. In Kullberg's flat rim balance there is also an inverted Arnold bar, and the flat

FIG. 6.

rims perform the same functions as the loops in Dent's balance do. In these days there are many other forms of balances, indeed, every maker of eminence may be said to have one of his own, but they are mostly modifications of the above. Indeed, the Arnold bar, so frequently repeated, seems itself to be a modification of a balance of Hardy's, in 1804. In all these compound lamina, the brass being the weaker metal is made thicker than the steel, from 2 to 1 to 3 to 2 being usual proportions. Although much thicker than the balance spring, the lamina follow a change of temperature with great rapidity. On one occasion, in order to test this, a chronometer was suddenly removed from a temperature of 103° into a temperature of about 28°, and, after two hours' interval, the difference in time amounted to no more than 0·3 second. After a few years' action the lamina often seem to acquire more flexibility, and, therefore, in new work, it is desirable to leave the compensation, if anything, a little slow in the heat.

*For Fig. 4 the Institution is indebted to Mr. Buckney, and for Figs. 5 and 6 to Messrs. Cassell & Co.

Methods of Rating.

The first annual trials of chronometers were commenced at the Royal Observatory in the year 1822, and to stimulate improvements rewards of £300 and £200 were offered respectively for the two best chronometers of each year. Afterward, the rewards became £200, £170, £130 for the three best chronometers of each year.

The method by which the chronometers were classified was as follows: The chronometers were compared every day, and at the end of each month the daily rates during that month were added together, and an average obtained by dividing by the number of days in that month. Then at the termination of the trial the difference between the greatest and least monthly average was sought out, and this difference was called the "extreme variation." The difference between the greatest and the least daily rate in each month was also sought out, and the average of these for the total number of months was obtained. After the "extreme variation" had been multiplied by two, this latter average was added to it, and the sum of the two gave the position number. Of course, the smaller the number, the higher the position was that it gave. The following table, giving the results of these trials, may be of interest:

Year.	Trial number.	Extreme variation.	Temperature.
1823	11·29	3·86	25° to 80°
1824	4·4	1·1	34 „ 70
1825	5·4	1·3	36 „ 70
1826	2·6	0·6	35 „ 82
1827	4·6	1·5	29 „ 79
1828	4·4	1·4	25 „ 78
1829	2·2	0·5	29 „ 73
1830	3·5	0·9	28 „ 80
1831	2·9	0·7	27 „ 78
1832	2·8	0·6	29 „ 78
1833	3·1	0·8	37 „ 77
1836	4·2	1·2	40 „ 81

As you may see from the temperatures given above, chronometers were at that time only exposed to natural ranges of temperatures, and it was not until about forty years ago that artificial heat was made use of in testing them. On the other hand, chronometers are not now exposed to the severity of out-of-door cold as they were then; and of late years even the milder practice of opening the windows of the chronometer room in the winter has been abandoned. In these days chronometers are tried at Greenwich in a receptacle called an "oven." The oven is heated by gas, and there is an automatic governor to control the temperature. In addition to the ordinary registering thermometer, an instrument called a chronometrical thermometer is made use of. Supposing the range of temperature indicated by the registering thermometer to be 95° to 100°, one might wish to know whether the temperature had been mostly at 95° or mostly at 100°. Without exactly answering the question in terms, the chronometrical thermometer will tell us the amount of the temperature as distinct from its range. The chronometrical thermometer is really a chronometer, the balance of which is compensated the wrong way so as to magnify the change of temperature which an uncompensated watch would show. I will give an illustration of its use from the Greenwich trial of 1888 to 1889.

During the week of July 14 to 21 the mean temperature according to the thermometer was 62·3° and the chronometrical thermometer lost 129·4 seconds; but during the week July 28 to August 4 the mean temperature according to the thermometer was 61°, and the chronometrical thermometer lost 150 seconds. It is evident that, despite the reading of the thermometer, the latter was a warmer week than the former, because the chronometrical thermometer lost nearly eleven seconds more.

The chronometrical thermometer is timed to go right at 60°, and it accompanies the chronometers throughout their trials. The number of chronometers annually entered is about forty-five, and their trial in general lasts twenty-eight weeks. The trial used to commence in January and terminate in August, but it now commences in July and ends in January. It will be instructive to follow the course of one of these trials, say that for 1887–1888, which commenced on the 2d of July.

For the first six weeks the temperature was tolerably uniform, the thermometer averaging 70°, and the weekly loss of the chronometrical thermometer being about 540 seconds. The seventh week was colder, the best indication of this being in the record of the chronometrical thermometer, which lost only seven seconds, while the mean of the thermometer was 63°. (I am not troubling you with the tenths of seconds or fractions of degrees.) The chronometers were now for the first time put in the oven, and remained there for a month, the average temperature being 94° by the thermometer, and a weekly loss of 2,650 seconds by the chronometrical thermometer. By this time the weather was growing colder, so that on their removal from the oven the chronometers experienced a sharp fall in temperature, the thermometer giving 59° and the chronometrical thermometer 278 seconds fast for the week which followed. The chronometers now remained in the natural temperature of the chronometer room for a period of six weeks, the temperature of the last week being 58° by the thermometer and 783 seconds fast by the chronometrical thermometer; they were then again placed in the oven. A further month in the oven ensued, the average of the thermometer being 94° and that of the chronometrical thermometer a weekly loss of about 2,700 seconds. The week in the last oven happened to be the hottest, the average of the thermometer being 99° and of the chronometrical thermometer a loss of over 3,000 seconds, and upon removal the chronometers again experienced a sharp fall in temperature, the first week out of the oven the thermometer giving an average of 53° and the chronometrical thermometer a gain of 869 seconds. The chronometers now remained in the natural temperature of the chronometer room until the termination of the trial, which took place on the 21st of January, seven weeks afterward, when the average of the thermometer was 48° and the weekly gain of the chro-

nometrical thermometer 1,272 seconds. There are no rewards now offered for chronometers at Greenwich, but a few of the best instruments which head the list are annually purchased for the use of the navy. Permission to enter chronometers must, in the first place, be obtained from the hydrographer, and makers of repute are generally allowed to send two. The method of classification which is adopted is as follows: The daily rates of each chronometer are added together, so as to form weekly rates, and it is only the weekly rates which are printed. Then, at the termination of the trial, the greatest difference which can be found between any two weekly rates of the same chronometer is sought out, and we will call this difference *a*. Again, the greatest difference between any one week and the next following is sought out, and this difference we will call *b*. Then the position number is obtained by adding *a* to 2*b*, and it is evident that the smaller it is, the better for the chronometer. The reason that *b* is doubled is that a sudden variation between one week and the next following is a much more serious defect than an error which has been gradually accumulating.

The first table of the Greenwich list gives the rate of each chronometer in the legitimate order of time in which it was taken. But on the succeeding page the rates of the chronometers are arranged in order of temperature as determined by the chronometrical thermometer. The object of this most useful arrangement is to enable errors of compensation to be tracked out with ease and certainty. It is astonishing with what regularity the rate of a chronometer, which presents the most perplexing discrepancies when read from week to week, will sometimes arrange its rate when read in this order of temperature as determined by the chronometrical thermometer. In point of fact, the chronometer itself might sometimes be used as a chronometrical thermometer, Plenty of illustrations of this can be found in the Greenwich list, and if you will divide the errors of the chronometrical thermometer by a fixed number, so as to approximate them to the errors of the chronometer, and then deduct the one from the other, you will find what the chronometer might have been but for the oversight of the maker. Indeed, the Greenwich list, though it may seem to the uninitiated but a mass of figures, is most interesting and instructive reading. Look at the first and last weeks of each list, and you will see how large a proportion of the instruments continue to be afflicted with the error of acceleration, that tendency to gain upon the rate which I told you of. Again, you may find examples of chronometers which "trip," in which the escapement fails, and the time of which advances by fits and starts some seconds. In many of the chronometers the balances get "set" on coming out of the oven, and then the rate is permanently changed. In other chronometers the oil may run away, and then the rates of such become very unsettled. This question of the oil is a real difficulty to chronometer makers. To begin with, the oil has to be exceedingly fluid, otherwise it would congeal in cold weather, and it follows that unless very little is put there may be some difficulty in retaining it at the points of the pivots, for the pivots being coned the oil has a tendency to creep up the cone, and you may often notice the effect of the shifting of the oil on the chronometer in high temperatures, even when the oil does not permanently run away. It is therefore not at all desirable that chronometers should be subjected to high temperatures immediately prior to going on a voyage, and every chronometer which is purchased at the annual trial has to be cleaned and recoiled subsequently by the maker.

I have made the following comparison of the average position number of the first ten and of the whole of chronometers on trial at Greenwich for certain years; and add the temperatures, as they may be interesting.

Year.	Average position. Number—First ten.	Average position. Number—Whole.	Temperature.
1868	33·7	52·6	36° to 96°
1869	20·9	41·8	39 " 100
1870	24·6	....	33 " 95
1874	24·4	....	36 " 96
1875	23·3	53·0	40 " 92
1880	30·2	54·5	24 " 104
1881	27·4	56·4	31 " 106
1884	24·0	...	44 " 105
1885	25·2	44·5	41 " 106
1887–88	24·5	45·0	37 " 99
1888–89	18·5	45·7	41 " 98

I will now briefly describe to you a method of rating chronometers which has been invented and developed by Mr. Hartnup, Chief Astronomer of the Liverpool Observatory, which seems to be of extraordinary power and utility. The Liverpool Observatory is the property of the Mersey Docks and Harbor Board, and great numbers of chronometers are brought from the mercantile marine to the observatory for the purpose of being rated. Most of these chronometers have naturally no secondary compensation, and in many of them the primary compensation has either never been adjusted with care or else has got out of order by lapse of time. Mr. Hartnup's method is to try these chronometers in three definite temperatures for five consecutive weeks in the following order of temperature: 55°, 70°, 85°, 70°, 55° and his object is to provide data for the calculation of their rates at other tempertures. Moreover, it is evident that the changes of temperature being systematically arranged so as to return to the same temperature after a given interval enable one to distinguish whether the change of rate, if any, is due to change of temperature or to some other cause. Now you will remember when I was speaking of the secondary error, I mentioned that it could be so divided as to leave the chronometer losing in the heat and losing in the cold; as Mr. Hartnup puts it, there exists for every chronometer a temperature on either side of which the chronometer will have a tendency to lose. From the data which he obtains by rating the chronometers as above, and by a series of equations, Mr. Hartnup is enabled to find T, the temperature on either side of which the chronometer will lose; R, the rate of the chronometer at that temperature; and C, the coefficient which when multiplied by the square of any number of degrees from T gives the amount of loss for that number of degrees. I give the following example from Mr. Hartnup's report:

Mean Daily Rates.

	55 deg.	70 deg.	5 deg.
	s.	s.	s.
Chronometer A.....	−3·0	−2·0	−3·1
" B.....	+3·7	+1·3	−2·2
" C.....	−3·5	+0·2	+2·2

You see that chronometer A loses equally on each side of 70°, and is therefore well adapted to ordinary voyages. Chronometer B has all its error slow in heat, and according to calculation would be most suitable for use in a temperature of 9°. While chronometer C, having all its error in the direction of the cold, would be best adapted for use in a temperature of 104°. From data obtained from comparison of upward of 1,000 chronometers, Mr. Hartnup has found an average value 0·0025 for the coefficient C, but of course C varies for each particular instrument. By the methods above stated it is within Mr. Hartnup's power to assign rates corresponding to different temperatures, and in practice the navigator would consult his thermometer and then add the corresponding rate. The following is an example of such a rate:

Rates to be added according to Temperature.

	s.		s.
45°.....	+2·2	75°.....	+3·8
50.....	+2·8	80.....	+3·6
55.....	+3·2	85.....	+3·3
60.....	+3·5	90.....	+2·9
65.....	+3·7	95.....	+2·3
70.....	+3·9		

The exactitude with which chronometers follow the rates which have been forecast for them is very surprising. And Mr. Hartnup, in his report of 1883, compares the performance of the chronometers of the Pacific Steam Navigation Company with the performance of the chronometers on trial at Greenwich, the changes of temperature experienced by each being very similar. I am sorry I have no time to follow Mr. Hartnup through his most interesting remarks, but breaking up the chronometers into three divisions he arrives at the following result:

In the case of the Pacific Steam Navigation Company, average difference of daily rate between one voyage of 105 days and the next following of the same length:

One-third best.	One-third second best.	One-third worst.
0·14 second.	0·31 second.	0·66 second.

In the case of the chronometers at Greenwich, average difference of daily rate between the first and second 98 days of trial in the year 1880:

One-third best.	One-third second best.	One-third worst.
0·88 second.	1·25 second.	1·96 second.

You see that the chronometers rated upon Mr. Hartnup's principle have by far the best of it; and although the year 1880, at Greenwich, was rather a poor one, it is evidently not sufficient to account for the difference, nor to invalidate Mr. Hartnup's comparison to any sufficient degree. I may add that Mr. Hartnup's system is now employed by the government of the United States, and also at the Kew Observatory, where chronometers can now be rated and certificates obtained.

I must not close this paper without speaking a word upon the subject of magnetism. The effect of magnetism upon a chronometer is disastrous, and when once thoroughly imparted, it is almost impossible to remove magnetism. A portion of the trial of each chronometer at the Royal Observatory is devoted to trying it with the 12 o'clock placed in turn toward each quarter of the compass. In general, chronometers so rated there are not found to be affected by magnetism, but it is a question whether the same would hold good for chronometers placed on board a modern war vessel, where electrical appliances are so abundant. Had I had time, I should much have liked to have compared some of the sea-going rates of chronometers under such conditions with the rates issued on shore. It is very possible that in the not very distant future, ships' chronometers, like the watches used by electrical engineers, will have to be rendered "non-magnetizable."

POTASH AND SODA FOR WASHING WOOLEN YARN AND CLOTH.

IT has been repeatedly pointed out, says a writer in the *Deutsche Wollen-Gewerbe*, that for washing wool and piece goods the potash treatment, in many respects, is better for the wool fiber than soda, and that it is advisable to use potash either alone or in the form of soft soap for this purpose. Although the correctness of this assertion is still doubted by many, it is a fact, established by numerous experiments, that the effect of potash upon wool fiber differs in several important particulars from that of soda. This is easily explained, for although the two materials have one point in common, being both alkaline, and in their combination with carbonic acid serve as detergents, they are, in other respects, agents of different natures, and in their chemical reactions vary entirely from each other. In England and the United States, where the use of potash is far more general than in Germany, it is said that wool washed with potash is much finer and silkier in touch than that washed with soda, and is not so liable to become yellow. The experiments referred to confirmed the truth of these assertions. It was ascertained that samples of precisely the same grade of wool, treated with these two agents, showed that the one washed with soda was much harsher in feel than the one washed with potash, and, after drying, it assumed a yellowish tinge not visible in the sample treated with potash. The chemical process which produces the yellow tinge upon the wool with soda is still not sufficiently well explained.

It is possible, however, that the influence of the soda upon the covering of the wool fiber, which contains fairly large quantities of sulphur, produces the yellow tinge by liberating the latter. Potash has no such reaction. On the contrary, it has a bleaching effect. The harsher feel produced by the soda shows that it attacks the surface of this fiber more strongly than potash. Even the fact that the wool yolk impregnated only with potash salts, but never with soda or its salts, is sufficient to show that potash is more appropriate than soda, and this is generally accepted where potash and the soft soap prepared therefrom have been employed. Complaints that wool became harsh and yellow were far less frequent formerly when wool was washed with urine, or the goods washed and fulled with earth and potash soap. This injury to the fabric is partly due to misuse of soda or unduly strong lyes.

The use of these agents, however, is required to-day by many of the grades of wool used in the textile industry, especially foreign wools. The necessity of employing larger quantities of lye is the reason why soda is used as a detergent, for potash would be too costly. But whether it is wise to chiefly regard the cost is doubtful, to say the least. The consideration of price should be left entirely out of view when it is desired to obtain a white and soft wool. The manufacturer who produces white goods, cloths, blankets, flannels, etc., should never use any other detergent than either potash or potash soap. Experience shows that soda, even under entirely normal conditions, exerts an injurious influence on the wool fiber, and this fact is now becoming well understood. As a proof of this, experiments to obtain a milder detergent have been made for a long time, and carbonate of ammonia, a milder form of soda, has been employed for wool washing for a number of years, this agent being preferred to the ordinary soda, at least where the preservation of the good qualities of the wool fiber is desired.

From a financial point of view, however, the situation is less favorable, because greater quantities of ammonia soda, as well as stronger lyes, are necessary. Besides this, cases occur, when filthy and dirty wool is to be washed, where ammonia soda, even if used in larger quantities, is not as effective as it should be, and the bath must be strengthened with calcined soda. Notwithstanding this, however, the use of ammonia soda is advisable for fairly clean wool, as this will give it a soft feel and clean appearance, similar to that washed with potash. Potash lye and soft soap are very excellent agents for the scouring of yarn, and should be preferred to soda lye and hard soap, especially when finer qualities of white yarn are to be treated, and it is necessary to have them soft and supple. A recipe for a washing process, which was formerly used very successfully in England, consisted in treating the yarn coming from the spinning frame with potash lye (2½ oz. potash to 10 lb. of water) at a temperature of 48° R. [148° F.] The yarn was then to be rinsed with warm water, and afterward passed through a slightly acid bath of sulphuric acid (2 oz. to 10 lb. of water), in order to neutralize the excess of potash.

It is worthy of mention that in this process (Harris') a vacuum apparatus was used. The yarn was placed in a cylinder, which was closed hermetically, a vacuum being generated by means of an air pump. The scouring liquor was then introduced. Air was again admitted in order to increase the action of the lye upon the yarn. The yarn was squeezed out after twenty minutes, and the liquor decanted. The excess of lye was, in the same manner, neutralized by a treatment with sulphuric acid. Soft soap and a little ammonia liquor are the best detergents for fine yarn. Soft soap of medium strength is also excellent for scouring the cloth before fulling. By a little attention, it will become just as clean as when treated with soda, but remains softer in the feel.

There is far less danger that the colors will be attacked or that the pieces will become hard and boardlike, as is the case with the least inattention where soda is used. Soft soap and fuller's earth were formerly the only agents used for scouring before fulling. They have been compelled, however, in nearly all mills, to give way before soda, the use of which has become more extensive since red oil was first employed as a lubricant in the spinning mill. The oils used before that time were nearly all of a vegetable origin, such as rape oil, olive oil, etc., and could not be expelled as easily by soda as they could be by potash soap and fuller's earth.

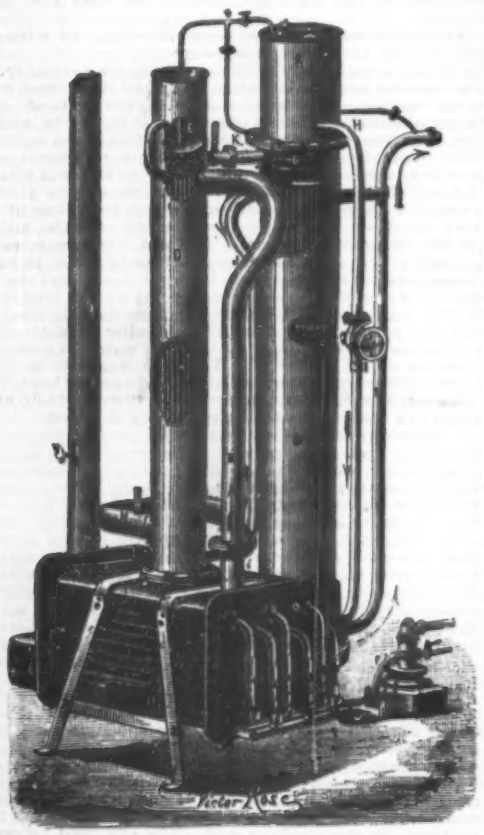
On the other hand, red oil is easily saponified with soda, and the use of this powerful and at the same time cheap alkali readily suggested itself for scouring purposes. Of course, the operator who uses it must exercise great care. If soda is used judiciously, it is not so dangerous, the action of this alkali being counteracted by the oil contained in the wool. But the difficulty is to calculate the quantity of soda and the strength of the lye to be employed in neutralizing the oil and greasy substances contained in the cloth. Even if the intelligent workman were to succeed in this undertaking, has not the manufacturer to deal with the ignorant and thoughtless help? If the lye is too weak, the cloth is not cleansed; if too strong, the excess of alkali injures the wool fiber and makes it harsh and dry. Many fullers adhere to the rule that it is better to take too much soda than too little, and do not take into consideration how much they injure both the appearance and the quality of the cloth. The finisher knows too well how often he is called upon to expend his art on hard, boardlike pieces of goods, which, even though he may exert his best efforts, will never become soft and pliable, while yellow and dirty-looking goods can never be bleached, no matter how much they may be sulphured. All these disagreeable occurrences are avoided by using only soft soap for the washing of woolen cloths prior to fulling, that is, a soap containing the correct proportion of alkali. The increased cost of this detergent is more than compensated by the improved quality of the cloth. It is, of course, a primary condition that the soap be free from adulterations, such as starch, water glass, etc. The manufacturer is sorely tempted to use adulterants, and the fact that the soap is often marketed in this condition has contributed not a little to the general introduction of soda. The ammonia soda has recently been employed for stuff washing, but for this purpose soft soap is preferable.

AUTOMATIC HEATING OF WINES.

THE heating of wine dates from the beginning of our century. It was done at that epoch, in the southern part of France, for the purpose of aging wines designed for shipment to a distance.

Later on, the labors of Mr. Pasteur demonstrated the advantage that might be obtained from heating wines, as regards their preservation. Mr. Houdart, who has devoted a great deal of attention to the subject, has devised an apparatus (which Mr. Eyrot is constructing) for the automatic heating of the ordinary wines of commerce. This apparatus consists of three parts: A boiler, a wine heater and a refrigeratory.

In the thermo-siphon boiler, D, the water designed to transmit heat to the wine is heated. The heating is effected either by gas or steam, but never by direct fire. It is the only means of obtaining a constant and uniform temperature. The figure shows a boiler in which the heating is done by a series of gas burners, the flame of which is directed into seamless copper tubes, which, after traversing the water several times, end at the draught chimney. At F may be seen an automatic temperature regulator, which regulates the discharge of the burners and is regulated by the temperature of the wine itself. C is the wine heater, in which the wine is heated by the water through a large number of long tubes of small diameter. The wine circulates slowly in these tin-lined tubes, so that its molecules remain for a long time in contact with the sides of the tubes, heated exactly to the desired temperature (62° to 65°). B is the refrigeratory in which the hot wine is cooled in contact with the cold wine that circulates in an arrangement of tubes identical with the one just mentioned. This refrigeratory is surmounted by a reservoir, A, into which the wine is introduced through a float cock that keeps the level of the wine constant, so as to effect a



APPARATUS FOR THE AUTOMATIC HEATING OF WINE.

very regular discharge, which is regulated by means of a cock, I, provided with a dial. Two thermometers mark the maximum temperature of the heated wine and that of the water in the boiler.

The various elements of the apparatus are easily taken apart, the heating and cooling surfaces are very wide, and, finally, the whole responds to the theoretical conditions prescribed by Mr. Pasteur, to wit: (1) heating of the wine protected against contact with the air; (2) regular and automatic heating in the boiler, the water being at a temperature near that to which it is desired to bring the wine; (3) a nearly perfect cooling of the wine before its exit from the apparatus, so that the air may not alter it; and (4) preservation of the gases and aromas that the wine holds in solution before the heating.

There are four types of this apparatus. The largest permits of heating from 750 to 800 gallons of wine per hour to a temperature of 60°. The price of the apparatus designed to be heated by gas is about $1,200.—*Annales Industrielles.*

REFINED WOOL.

By E. J. FISCHER.

IT is well known that hair and wool are of tubular structure, the tubular cavity serving as a duct for an oily substance supplied by the animal to keep the wool soft and pliable.

When the wool is removed from an animal, the oil within this tubular cavity or duct dries and becomes hard, thus forming a pith or marrow, which is not removed by any of the cleansing processes usually practiced, and this oily or fatty substance or impurity within the cavity of the wool imparts color to the wool after cleansing, and also prevents its thorough impregnation with dyes.

The processes heretofore employed for cleansing hair and wool only serve to free the material under treatment from the natural surface coating or "yelk" and foreign matters adhering to the surface, that have a tendency to repel the dye.

A refining of the fiber by the removal of this pith or marrow would effect some very desirable results, as will be seen by the following notes, extract of a paper lately read before the Custom Cutters' Association:

We are compelled through necessity to import English woolens.

To manufacture good woolens requires four years' process of the wool.

In each fiber of the wool is a cavity which contains oil. It cannot be washed or scoured out, it must be thoroughly dried.

The American manufacturer will not take the time to place his wool in proper condition. The shrinking of the raw material and the protracted investment of his money urge him to use wool improperly prepared. In dyeing such wool the oil which remains repels the coloring. It also causes the shrinkage which is so objectionable in domestic woolens.

Superior texture attained. The softness of fine clothing wool is next in importance to the fineness of the fiber, and consists in the peculiar feel, which approaches to that of silk or down.

In the harder wool the fiber is elastic and hard to the touch, and cloth made from it has the same hard feel. It is also more loose in its texture.

The difference in the value of cloth from two kinds of wool, equally fine, but one distinguished for its softness and the other for the contrary quality, is such that, with the same process and expense of manufacture, the former will make a cloth more valuable than the other from 25 to 50 per cent.

By the employment of such refining upon the best grades of our wool, we may be enabled to obtain an article equal to the celebrated India product. As this treatment has a tendency to bring about a condition of greater softness of texture in wool, as also greater beauty and luster in mohair and camel's hair, besides a capability of absorbing the dyes more thoroughly, owing to the extraction of fatty matter from the tubular cavity. It is very evident that if the American manufacturer of woolens desires to successfully compete with the foreign make, he will have to commence at the outset with the treatment of the crude material, which should necessarily be in a condition so as to admit of the subsequent processes of manufacture resulting in a material and of a finish *par excellence.*

LESS SUSCEPTIBLE TO MOTHS.

It appears rather conclusive that the chief nourishment for moths consists in the pith of the woolen or fur fiber, since the more vitality the fiber as yet contains, the greater the liability of such to become the prey of the pest.

FINER FELT AS A RESULT.

Wool and hair having the pith removed will also felt much more readily and result in a closer as well as finer article.

All these results considered, and the fact that it will result in the production of a woolen garment free of all animal matter other than the true fiber, with slight liability of shrinkage after being made up, should make this subject one of universal interest.

HOW ACCOMPLISHED.

The next practical question arises as to how this marrow or hard pith may be removed without injury to the fiber itself.

After the wool has received the customary cleansing, such as washing and scouring, to remove the external impurities, the same should be placed into a vat provided with a false bottom, and beneath this a discharge opening, care being taken not to crowd or pack the material, and then run in sufficient clear water (either cool or lukewarm) to completely cover the material under treatment.

This charge of water is allowed to remain in the vat twenty-four hours, and is then drawn off through the discharge opening below the false bottom, said false bottom serving to prevent the loss of any of the material under treatment, though permitting the passage of any impurities that have been removed from the surface of said material. Another charge of clear water is then run in the vat and allowed to stand about the same length of time as the first charge, and this changing of the charges of water is continued for thirty days, or thereabout, the material having become by its continued submersion very soft and somewhat water soaked.

When the material under treatment has attained this condition, it will be found that the dried oil or fatty matter contained in the tubular cavities of the air or wool has become sufficiently soft for removal by a subsequent treatment.

The last charge of water should now be drawn off and a saturated solution of sal soda or any other saponifiable substance substituted, the material being allowed to remain in this solution for about a week, more or less, until the fatty pith or marrow within the tubular cavities of the fiber is taken up by the solution, which may be determined from the fact that the liquid of the bath takes the color of the matter removed from the cavity of the fiber.

During this step of the process it may be necessary to enrich the solution by the addition of sal soda or other ingredient used.

The material is now thoroughly washed in clear water, to free it from any chemical absorbed during the last step of the treatment, and then dried for use, as the surface impurities were removed early in the clear water stage of treatment.

The drying process may be hastened by first passing the material through a wringer, as is sometimes practiced. This process is inexpensive, as the saturated solution used therein may be recovered or restored by filtration through sand, gravel, and charcoal, and reused when strengthened or enriched by a small quantity of the sal soda or other ingredient.

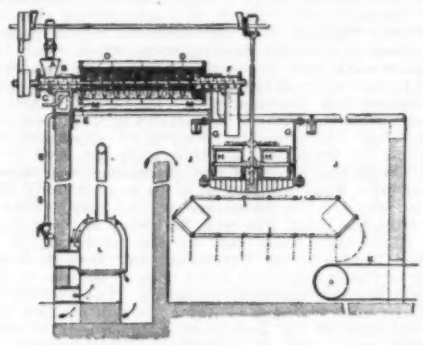
It will be observed that the solution employed to combine with the pith of the fiber should be of a saturated density or strength. This will then coat the fiber, and penetrate the same without the danger of the exhaustive influence such liquid would have if merely charged with the saponifiable substance.

PREPARATION OF CEREALS FOR BREWING.

By A. PERRY, London.

THE object is to render rice and other grain more suitable for brewing, distilling, vinegar making, and for purposes of food. For this purpose the grain is first submitted to the action of hot water to cook the grain and saccharify the starchy constituents. It is then shredded in a suitable machine, and the shreds removed and dried.

The apparatus used in the above processes is shown in the illustration. The rice or other grain is fed to the hopper and falls into the cylinder, B, where it is propelled by the helical blade, C, to the gauze cylinder, D. The gauze cylinder has secured in it a helical gauze blade, and revolves about its axis partly immersed in boiling water. The water is heated by steam supplied through pipe, E. As the cylinder, D, revolves, the rice is conveyed by its helical blade along the cylinder until it is finally discharged in the cylinder, F, from which it passes to the shredding machine. During its travel through the gauze cylinder the rice is partly cooked by the boiling water. The shredding machine is composed of a cylindrical vessel, G, with a perforated bottom. In the vessel are heavy rollers, H, which are revolved and roll over the surface of the perforated bottom. The rice, therefore, as it falls into the vessel, is forced through the perforations, and issues



in a thread-like shape. These shreds, as they fall from the shredding machine, are received upon the traveling belt, I, which conducts them through a heated chamber, J, to dry them. The dried shreds are finally removed from the chamber by a second belt, K. The chamber is heated by a furnace, L, which can also be made to heat the boiler supplying steam to the trough, M.

IMPROVED AUTOMATIC TENSION FOR DRIVING ROPES.

THE old principle was to have one rope to one groove, and to have several ropes to one drive, and the difficulty was to get all the ropes on one drive of exactly the same diameter, as, when some were in the slightest degree less than others, they would fall deeper in the groove, and thus attempt to drive the driven pulley at a different speed from the others, but as this was impossible, some used to slip, and thus put a brake on the pulley. Hence the waste of power. To obviate this difficulty, many devices have been brought out, among such has been a continuous rope wound spirally round the pulleys, but with a rigid tightener, which does not allow for any extra power that may be put on, or for

IMPROVED DRIVING ROPES.

any atmospheric changes, thus only partly remedying the evil. But Mr. Rateliffe, of Newton Moor, has invented a system of a continuous rope, with an automatic tightener, which is very accommodating, as it requires no adjustment whatever after it is once started, the rope being always kept at one uniform tension throughout by a weighted pulley, over which the slack side of the rope passes, which weight, of course, can be increased or diminished according to the power wished to be transmitted.—*Journal of Fabrics.*

THE ARC LIGHT FOR PROJECTION.*

By Dr. L. H. LAUDY.

A GENERAL adoption of the electric arc light for purposes of projection is not far distant, and having devoted some time to the subject, following it up from the days in which the current was produced from batteries until to-day, when we have on tap a current of electricity as we have gas or water supplies, it seems most fitting that my experience should be given to the members of this society, and my object in inviting you here this evening is to give you some experimental facts, and ask your verdict as to its application for lantern projections.

Our usual method has been to make use of incandescent lime. This was a great advance from the oil lamp, and to-night we take probably the last step in this direction of improved illumination and make use of the most intense artificial light known to science.

Artificial light is generally produced by raising some body to a high temperature. If the temperature of the body be greater than that of the surrounding atmosphere, it parts with some of its energy in the form of radiation, and at a high temperature this radiation becomes sensible to the eye, passing from red, yellow, green to blue and violet. At the present time for all artificial illumination the radiant body is some form of carbon, either incandescent or combining with the oxygen of the air.

The electric light is the outgrowth of the experiments of Sir Humphry Davy, made at the Royal Institute, London, in 1801, when he used 2,000 cells, with which he decomposed Na and K and separated their metallic bases.

These experiments were repeated and extended, and by using charcoal points as terminals an intense and dazzling light was produced, to which the name voltaic arc was given. Foucault used a more dense form of carbon for his newly invented lamp or regulator, producing a more steady and uniform light.

The arc light when produced from a battery, brilliant as it is, was confined to the lecture room or an occasional outdoor display. The fatal difficulty was the labor and cost of the electrical energy, and it was not until the discovery of induced currents by Faraday that this obstacle was removed.

It was many years before any practical application was made of this most important electrical discovery, and it required the combined forces of Nollett, Von Maldern, Holmes, Wilde, Ladd and Siemens to produce by mechanical means, direct from motion, a supply of electrical energy that would equal that produced from the battery. Even as late as 1870 this did not seem possible, for the best dynamos at that time yielded only a small amount of electrical energy.

In 1871 Gramme presented to the Academy of Science a description of a new form of magneto-electric machine possessing new features, which were so remarkable as to astonish all the world. Gramme conceived the idea of using a ring, and rotating this between the poles of a magnet in such a way as to prevent reversals in the armature. Many ridiculed this idea. Nevertheless it produced in practice a machine that yielded large currents at much less cost, and laid the foundation of our present system of electric lighting.

From whatever source the electricity is supplied to produce light, it is necessary that the current meets with a resistance, and this condition is best fulfilled when two pieces of carbon are made to touch and then slightly separated. The current in passing between the space so increases the resistance as to produce light of great intensity, and is called the arc light.

That a constant resistance may be maintained favorable to the production of light, some mechanical device that will separate and regulate the distance of the carbons is essential.

Such an apparatus is called a regulator or arc lamp.

There are few inventions on which so much ingenuity has been expended as on arc lamps. The number is already very great and is on the increase, and every bulletin of the patent office is sure to contain several inventions of this kind.

Between the better lamps there is not much to choose for ordinary illumination, but for special purposes, as in the case of lantern projection, some points are of vital importance, for the success will depend mainly upon the steadiness, good behavior, and the excellence of the automatic feed quality and position of the carbons, together with a uniform action of the dynamos.

At present arc lights are run both by continuous and by alternating currents, *i. e.*, in some cases the current is steadily in the same direction, while in others the current consists of pulses, alternately positive and negative, succeeding each other at the rate of from 200 to 300 per second.

The first lamp for regulating the position of the carbons was devised by Thomas Wright, of London, in 1845. A few years later Le Molt, of France, devised a clockwork regulator which kept the light steady for several minutes at a time, but the flickering was too great to make it of any practical value. These were followed by Archerean, Lacassagre and Garffe, each lamp an improvement on the other, which brought the standard of regulators near to practical application.

In 1849 Foucault devised a clockwork regulator that differed in many details from the ones before used, and gave comparative satisfaction. It was extensively employed for scientific purposes, and, in fact, was the only lamp that was suitable for lantern projection, and is to-day used in many physical laboratories in preference to other lamps.

The next advance was by Serrin, whose regulator kept the carbons exceedingly steady and maintained them in their relative positions. This lamp has been used for lighthouse illumination and still maintains that position, for, like the Foucault, it is a focusing lamp, the function of which is to maintain the carbons at a central point. To produce this effect the carbons are so arranged that a different motion is imparted to each, that the wearing away may be compensated for by a more rapid movement of the positive pole, with only a gradual waste of the negative carbon. By this simultaneous approach of both carbons, the positive moving through double the distance of the negative, the arc preserves its normal length and its position is maintained in space. This is accomplished by an ingenious mechanical device, actuated either by clockwork or electric magnets.

The regulation of the length of arc that shall produce the most intense light with the least current is confined to very narrow limits, and the mechanical construction of the lamp that will yield satisfactory results must be most perfect. In many of the lamps this regulation is still wanting, and lamps lacking the above essentials, that are put together without regard to any electrical laws, with the hope that chance may make them work, produce a hissing and hammering noise that is disagreeable when silence is required, and are not to be recommended for any purpose.

However well the regulation, due to the electrical and mechanical part of the lamp, they cannot regulate the minute accidental variations in the structure of the carbons, which causes a shifting of the arc or chasing, and as the arc flies around, the direction of maximum emission will change with it. These fluctuations produce immense variation in the intensity of the light, changing back and forth from 400 to 2,000 candles. Great improvements have been effected in the homogeneity of the carbons, and the time is not far distant when the flickering will be entirely removed.

The mechanical and electrical regulating devices are all that could be desired, and at present the light is not too irregular to be adopted for purposes of projection. With any good regulation results may be obtained that far exceed in brilliancy any of the old methods employed.

This matter of increased intensity is of great importance, especially in large public halls, where in many cases the picture is enlarged many hundred times without regard to the diminished light produced by means of the oxyhydrogen light.

In considering the application of the electric light as a source of illumination, it is very important to notice just what position the carbon poles must occupy in relation to certain requirements.

For outdoor illumination the axes should coincide, that the crater formed in the upper carbon may act as a reflector, and thus produce an increased downward illumination.

Advantage is taken of the crater-like reflection to cast the rays at variable angles in a given direction.

To obtain the best effects for lantern projections the carbons are arranged so the axis of the upper carbon coincides with the edge of the lower carbon farthest from the condenser. In this position of the carbons the light will be concentrated upon one side and radiate freely in front, will be cut off from behind, with little escape at either side. From this it follows that many different results can be obtained, depending upon the position of the carbon.

CLASSIFICATION.

It is more or less difficult to make a classification of arc lamps in their present state, or divide them into a few distinctive types.

The old classification divided them into monophotal and polyphotal.

In the former the electro-magnet system, which produces the adjustment of the distance of the carbons, is traversed by the main current and is adjusted for a constant current. This prevents a number of lamps being placed in series, as the approach of the carbons is produced by mechanical means independent of the current.

Polyphotal lamps are adjusted for a constant resistance of the arc. This is effected by placing the regulating apparatus in a shunt of the main current, which is also supplied with a cut-out device to short-circuit the lamp in the event of a disconnection in the arc.

The objection to this classification is that one would be transferred to the other by an alteration in the winding of the coils.

The better or later division is to class them either as series or parallel, which is dependent upon electrical conditions rather than mechanical. We may again subdivide them as a matter of convenience into—

1. Hand regulation.
2. Actuated by a spring (clockwork).
3. Train of wheels and gravity.
4. Differential and gravity.
5. Clutch and dash pot
6. Electro-motor.
7. Focusing.
8. Electro-magnet and dash pot.
9. Lever movement.

The most important consideration is simplicity of construction and sensitive motion of carbons, with speed to allow of instantaneous adjustment.

These conditions are changing at each variation of resistance, which alters with the change of temperature in the conductor, and this again varies the potential, so that it is impossible to keep the arc constant. For any increase in the current the wire coils are heated with an increase of resistance in the lamp. To regulate these variations and to secure the proper proportions we meet with colliding difficulties and are confined to narrow limits in order to reconcile them.

The necessary features in construction of a lamp are:

1. *Striking* mechanism or separating the carbons.
2. *Feeding.*
3. *Replacing*, to put in new carbons (trimming).
4. *Moderating*, to prevent carbons striking or hammering.
5. *Change over* for two carbons.
6. *Cut out.*
7. *Clamps for carbons.*
8. *Driving power*, which may be clockwork, gravity, weights, electro-magnets, and electro-motors.

The operation of an arc lamp consists of two movements:

First. The withdrawal of the carbons or striking the arc, which is caused by a stout wire coil placed in the main circuit.

Second. The approach of the carbons, which is brought about by a thin wire coil of high resistance placed in the shunt.

There is also added a cut-out circuit, which consists of a shunt coil and a series coil. These are so wound as to help each other's magnetic power, and the series coil must itself be a shunt to the main circuit of the lamp. As the carbons burn away the arc gets longer and there is an increase in the resistance. This diminishes the current's strength in the magnets, and the carbons descend until they meet and again form the arc.

The design of the lamp depends upon the condition with which it is to be supplied with current. That is, whether it is supplied by a constant potential with variable current, as is furnished by the Edison company, or low tension current, that is having a voltage of 115 to 120 volts; or whether it is fed from a variable potential and constant current of high voltage, as is used in series arc lighting. This current is known as the high potential, and the voltage runs in most cases from 1,000 to 3,000 volts. The objection to the latter is that to make any adjustment of the lamp the current must be turned off, and the lamp cannot be handled with the current on without danger, possibly attended with fatal results.

The current used for projection should be the low tension, for with this the lamp can be handled without danger and all the adjustments may be made while the lamp is in operation.

When using the low tension current it is necessary to have some resistance in circuit, when operating with one lamp, to cut down the voltage and deliver the proper amount of current. This resistance may be either coils of wire or low resistance lamps placed two in series and three in parallel. With four or six of these lamps the proper voltage will be delivered to the arc regulator with a current of from ten to twelve amperes. This form of resistance is more compact and the lamps are now made for this special purpose.

The great advantage over all other methods of illumination is its small cost per candle power, its intensity, whiteness, and parallel rays. These properties make it especially well adapted for purposes of projection, as it admits a larger number of rays to pass through the optical center of the condenser.

The intensity of the arc light has been variously estimated at from 400 to 2,000 candle power. With a variable arc this will take place, but for purposes of projection this objectionable feature has been removed. With a proper position of carbons these changes in the intensity of the light fall within narrow limits, and the fluctuation due to the mechanical movements in the lamp is small, as the interval of the feed is about two seconds. The intensity of the light when the carbons are arranged as described for projection is from 1,200 to 1,500 candle power.

It is essential that the wires used to deliver the current to the regulator should be large enough to prevent heating, as all the heat must be made visible at the carbon points and none lost in the wires. It is better to have a separate set of wires starting as near the mains as possible with proper cut-out and fuses.

Estimates will be furnished by the company for this, as the work must be done by those skilled in the art, otherwise the proper conditions may not be fulfilled.

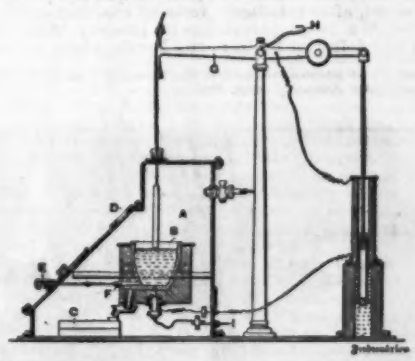
I have avoided using electrical and mathematical calculations, and to some this may seem a strange omission, while to others it will, I hope, make the article more readable.

* Read before Society of Amateur Photographers, New York.

ELECTRIC FURNACES.

By E. TAUSSIG, Badrenfeld, Germany.

THE object of this invention is to provide for the casting of objects with a smooth, non-oxidized surface, and to avoid the disadvantages arising from the admission of air during the melting and conveyance of the molten material to the casting apparatus and moulds. The metal is melted in a crucible, B, by electricity. The crucible and the moulds, C, are inclosed in a chamber, A, from which air is exhausted by any suitable means. To watch the process, the chamber, A, is provided with windows, D. The metal is poured by withdrawing the plug, F, attached to the handle, E. The heating device consists of a negative carbon rod, G, which is suspended with a Siemens electric furnace upon a balance lever, G. H and I are the negative and positive wires, leading to some source of electricity.



Claim: The method of melting and casting metal in a rarefied atmosphere consisting in arranging an electric melting furnace of suitable construction, with the casting apparatus and moulding boxes in a chamber within which the air may be suitably rarefied during the melting and casting, with means for controlling said parts from outside the chamber without disturbing the atmospheric pressure in said chamber.

ELECTRIC LAUNCHES AT THE EDINBURGH EXHIBITION.

PROPULSION by electricity is effectually demonstrated at the Edinburgh exhibition. The site favored this, as it is skirted by the Union canal, and four launches are running on the canal. These, says *Engineering*, were designed by Messrs. Morton & Williamson, Glasgow, and built by Messrs. T. B. Seath & Co., Rutherglen. The dimensions are 40 ft. long, 6 ft. 6 in. beam, and the draught of water is 2 ft. 1 in. They each carry forty passengers.

The electrical equipment has been supplied by Messrs. M. Immisch & Co., London, and is similar to that used on the Thames launches. The charging plant consists of a 25 horse power engine and an Immisch dynamo, and the switch arrangement is suitable for charging all the four launches at the same time. The recharging is done during the night, and the launch can run ten to twelve hours. The motors are capable of an output of about 3½ brake horse power, working up to

800 revolutions per minute, and the speed with the maximum load on board is six miles an hour. The propellers are coupled direct to the motor shafts. A ball bearing thrust block is attached to the motor's bed and is constructed in combination with the plain bearing of the motor. The steering, starting, and reversing gear is so arranged that one man has the launch entirely under control. These, so far as we can learn, are the first electric launches which have been worked commercially in Scotland.

FISHERY SKETCHES.

WE give from the London *Graphic* a few interesting sketches relating to American fishery industries.

THE HORSE'S HOOF.*

By Dr. WILLIAMSON BRYDEN.

THE variety of hoofs found under different circumstances and at different periods, and the information derived from a study of them in a state of nature and in domestication, reveal to us not only their susceptibility to favorable and unfavorable influences, but also the potency of different surroundings in accomplishing changes and modifications in their form, size, and quality.

A proper appreciation of this is indispensable to the breeder and the veterinarian who would cultivate the hoof successfully, for in proportion to our comprehension of the subject will be our ability to overcome in a more natural way undesirable deviations in its growth, the result not only of congenital influences, but also of acquired defects as well. When this is supplemented by judicious surgical skill, our ability to prevent, to improve, or even to overcome, defective forms and qualities will prove a most important accomplishment and lead to studies of the horse's locomotive organs that will be found of very great interest to students of comparative medicine and surgery, especially in branches such as orthopœdics and athletics.

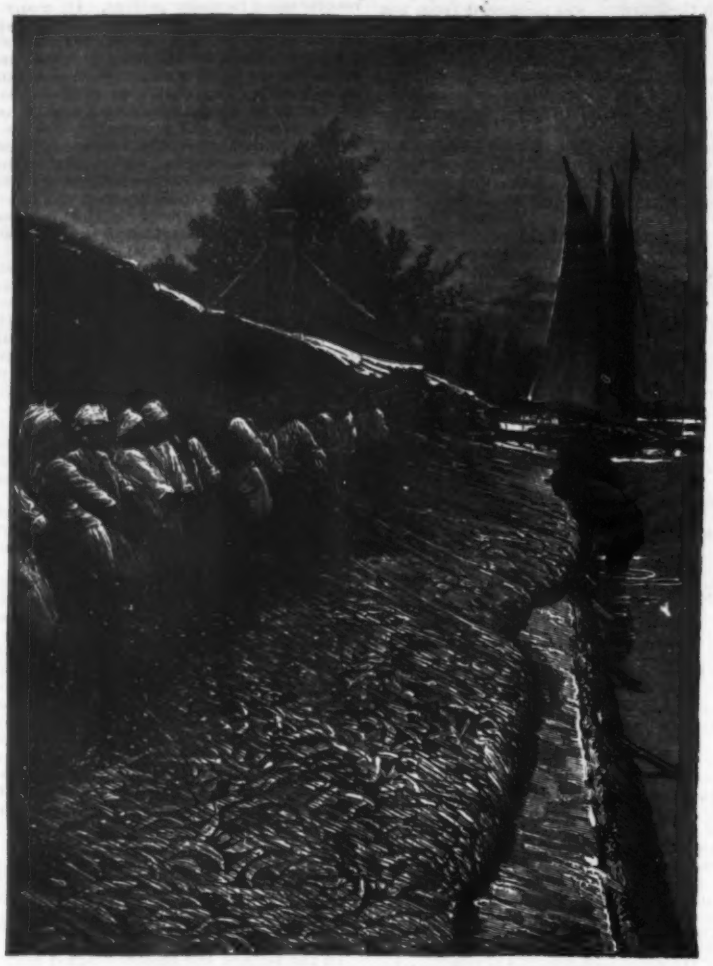
As illustrating the effect of climate, soil, and country in determining the character of the hoof, permit me to repeat what is told us by a celebrated African traveler (I think Sir Samuel Baker), that in Nubia and some districts on the banks of the river Nile, "asses have hoofs as large as our horses." This evidently comes from an excess of moisture in the ground on which they have been brought up.

We are also aware that the hoofs of horses raised in mild climates and on low soft ground are large and round, with frogs covering one-third of the area of the sole, while those raised on dry and hilly countries have smaller hoofs, from want of moisture and other causes.

The lesson this teaches when applied to an individual is, if a certain animal has hoofs that are small and dry, pasture him where the ground is soft and moist; if the hoofs are large and spongy, pasture on drier upland. On some farms there may be ground suitable for certain kinds of grain, while other parts of the same farm may be quite unfit for such a crop. It is much the same in selecting suitable pasturage for our young horses.

If a breed of animals of excellent quality, pedigree, and record, after intelligent tests by crossing, continue to produce a large percentage of progeny with poor hoofs and defective limbs in the North, where the winters are long, change them to farther south, where enough exercise all the year round can be assured, and the chances are that a desirable family of animals may be perpetuated, instead of being allowed to gradually drift to decrepitude.

* Abstract of address delivered at the Montreal Veterinary College, February, 1890.—*Journal of Comp. Med.*

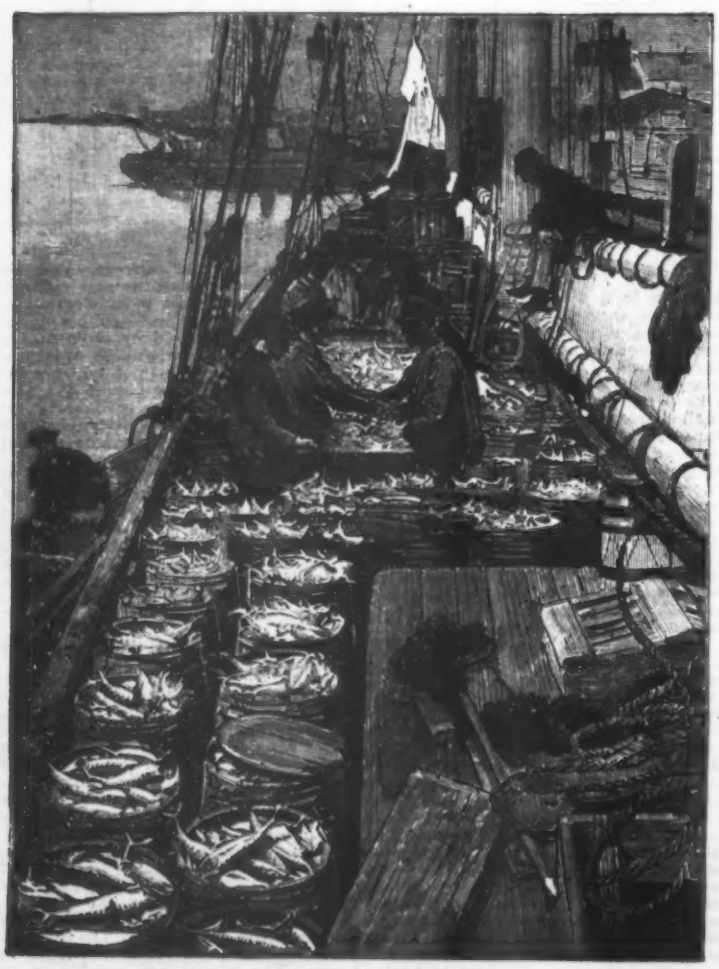


SHAD FISHING ON THE POTOMAC.

In every locality, even the most favorable, the restraints imposed by domestication yearly ruin many of our finest young animals, the want of *wear and tear* to the hoofs and exercise to the limbs being a most important factor in leading to such misfortunes.

Take, for example, a foal born a couple of months before the grass comes. It is confined in a pen, perhaps on dry plank floors, quite unsuitable for its tender little feet, which nature intended for a soft pasture. When spring opens, the weather may be dry, the soil poor or otherwise ill suited to repair the mischief. Another period of five or six months' imprisonment is soon reached, and this is repeated till maturity.

When we reflect that we have not merely a single organism, but that each animal has four hoofs, and that these and the limbs above must reach maturity in a fairly symmetrical and unblemished condition,



DRESSING A DECK OF MACKEREL.

COD DRYING ON FLAKES AT GLOUCESTER, MASSACHUSETTS.

the necessity for intelligent watchfulness and supervision becomes apparent.

To explain this more fully: Take a yearling. He is well bred, looks well and is free from any noticeable lameness. On examining his feet, however, it is found that he places one hind foot evenly on the ground; the other foot he places more on the toe. If this continues for a year or so during the growing period of his life, it is evident that among other changes in the hoofs, they will differ in shape, the heel of the one that bears most on the toe will be narrowest, and it is impossible that the limbs above can organize alike. Consequently their action or gait will be different, and also the predisposition to disease.

As an illustration of the effect on the limbs above when the weight is thrown irregularly on the hoof, or when pain or other disordered conditions of the foot re-acts on them, I will describe a five year old horse of good size and weight, as follows:

Near Side.—On the foreleg the hoof is of good size, but toes *in*, the outside heel is low, the fetlock hangs over it and has a small windgall outside and a small sprung ligament on the inner front. The ulna is *out* from the ribs, and the point of the shoulder is *in;* the scapula is too far forward on the neck, which is full and bulges a little to the side.

Off Side.—On the off foreleg the hoof is of good size, but *toes out;* the inside heel is low and the fetlock is over it. The ulna is close to the ribs and the scapula back on the shoulders.

Two such legs are unlike each other, and the gait is rocking and uneven.

The near foot describes a circle *out*, the off foot describes a circle *in*, and when trotting is liable to interfere with the other. Such a condition may be brought about when the foal suckles mostly on one side of the dam, especially in confined places, or it may be influenced by the way the attendant trims the hoofs of the young. If he is right handed, the rasp is used from different points of vision and positions. The same applies to the horseshoer. If he is right handed he levels the two feet for the shoe from the opposite points, and also sets the shoe and drives it in the same way. On the near foot he drives the second nail on the outside first, and on the off foot the second nail on the inside first.

Near Side Behind.—The hoof is of a fair size, but *toes in;* the outside heel is low, short and turned under; the fetlock is above this heel, and there is a puff above the sessamoid on the same side. Such a hoof binds at the coronet, and if scraped clean, where the hoof is white, it will show blood staining from the disturbance to the circulation by the tight coronet. The inside heel is long, well back, and slopes under. When this has existed for some time, the fetlock will cockle, the angle of the tibia and femur will be lengthened; the crest of the ilium is *up* and *in;* the ischium is in and down, and the tail is drawn toward the left, unless it was previously twisted too far to the other side; dimples, the result of atrophy, also appear over the hip articulation.

Off Side Behind.—The hoof is of fair size, but toes in; the outside heel is short and turned under; the fetlock is over the inside heel; the leg at the head of the metatarsal bone is bent inward, giving it a zigzag appearance when viewed from before or behind; the tendons behind the cannon bone do not overlap each other evenly; the summit of the calcis is pulled outward and causes a slight fullness below the base on the inner aspect; the stifle is out, and the crest of the ilium is not so prominent as the other, but the hip is wider and more fleshy and looks larger.

In the near hind foot just described we have one that predisposes or is liable to ordinary bone spavin, especially if the sole is concave and thick.

When, as I said before, the hoof is placed unevenly on the ground, either because there is a tender part or simply because it is most comfortable and has become a habit, the weight is unevenly distributed to the limb above, and it organizes in harmony with the defect in the hoof. If, for example, the hoof is placed on the ground in such a way that the metatarsal flexor has to do more than its share of work—when the animal is not too old—the gradual increased strain at its insertion leads to a projection at the seat of ordinary bone spavin. This may at first be healthy tissue, but when the inharmony in the organization of the limb has increased, from shortening of the muscle or other retrograde changes, the demand on the flexor or the parts of the hock involved is either too great or they are less able to meet this demand. True bone spavin, with its disastrous consequences to the animal, is the result.

One or both heels may shorten or grow thin between the bars and the external wall, or, if they are long, one or both may contract, sometimes uniformly; in other cases one more than the other. In contractions of this nature the bars are more upright and the commissures deep; the soft structures beneath are injured as with an ingrowing toe nail. This leads to atrophy, and even navicular disease in both fore and hind feet, or it may interfere with the circulation to the frog, and cause atrophy of it or even thrush.

In another form of contraction, familiarly known as hoofbound, the foot has been held firmly in its grasp for a long time, and the interference with the circulation gives rise to another class of diseases, such as scratches. Owing to the disturbed condition of the extremities, the waste is imperfectly carried off by the blood vessels and the thin skin behind the pastern performs this important function for them. In time chronic scratches supervene, and every time the animal is driven out they break out again—an excellent example of "disordered nutrition." This may continue still farther, especially in coarse-bred horses, and the whole foot become so disturbed that its secreting structures perform their function imperfectly, the walls become coarse and irregular, projections of horn are found transplanted and scattered over the heels and behind the pasterns; sometimes the disturbance is so great and long continued that the ergots and fetlock tufts of hair become mixed and grow in the form of a crust, reaching up and down the leg and familiarly known as rat tails. Even the horny tissues called the chestnuts change as the foot becomes disordered.

When the hoof has acquired such a character that it affects adversely the structures it was intended to protect, the limb above is affected, at first indirectly and without any important structural change, and any change of gait it may have occasioned can be instantly corrected.

If the limb was held suspended for a sufficiently long time, a general atrophy would result; but if the animal is kept at work, and he puts the weight on his foot irregularly, changes take place in certain parts of the limb from too much work, while the other parts of the same limb may be affected adversely from too little, or from not being required to perform their proportion of work.

We are all familiar with what has been called strain of the flexor tendons. Here the commissures deepen until the animal cannot comfortably rest his weight on his heel; going on his toe causes it to be brought directly under the leg, to relieve them. This is accomplished principally through the flexors, which are overtasked and strained; the surrounding structures, from the foot to the carpus, and even higher, become hypertrophied, and in the brachial region there is atrophy, while the most conspicuous feature of all is their having become greatly shortened. It is evident that such a case can be successfully treated only when the hoof is recognized as the cause, atrophy of structures within the hoof being easiest overcome when the mechanical pressure it exerts is relieved.

This shortening of structures in connection with atrophies and hypertrophies reminds me of a blunder I made in an article to the *Veterinarian* in 1876.

In trying to explain the importance of the hoof as the chief source of derangements of the limbs above, I stated that "the tail is drawn to the side on which the muscles are strongest." This I have since discovered to be a mistake, the animal I was taking my observations from having a kind of congenital twist or bend in her tail to the off side too great to be overcome by the shortening on the atrophied side.

In the study of animal organization this is a most important matter, as without a knowledge of this fact our explanations of many cases of imperfect organization are simply mysterious phenomena, impossible of being explained scientifically. It is a most important factor, too, in bringing about that inharmonious muscular organization that gives us erratic gaits, equivocal locomotive action, and many of those diseased conditions of the limbs to which horses are particularly liable. When so-called tarsal tenotomy has afforded relief, the *tension* has not always been due to increase of the subjacent bone, but to retrograde changes and shortening of the structures divided.

We are all familiar with muscular relaxation the result of an injury, where the tail, for example, would be drawn *to the side on which the muscles are strongest;* but where we have atrophies, etc., the result of what may be called peripheral disturbances, we have in many cases shortening of structures instead of relaxation.

In examining for bone spavin one of the most important points is the heel. Place the horse's hind feet together on a level floor and measure the heel of each shoe. If they are alike in size and width at the heel, the foot of the spavined limb being smallest, more of the shoe will be exposed than on the sound foot. Of coures this applies to other troubles of the leg as well, and is very important, as such a leg is always weaker than its fellow.

There are at least three kinds of hoofs peculiar to as many different forms of springhalt, and springhalt acquired during the growing period of the animal's life is generally more difficult to benefit than when acquired in adult life.

Anchylosis, specimens of bone spavin, etc., without any history, are mere curiosities, and every specimen to be of value ought to have been written up during life, and the hoofs, bones, and ligaments preserved.

SIMPLE EXPERIMENTS IN PHYSICS.

Experiment on atmospheric pressure.—Take a board about eight inches in width and twenty in length, and place it upon the edge of a table in such a

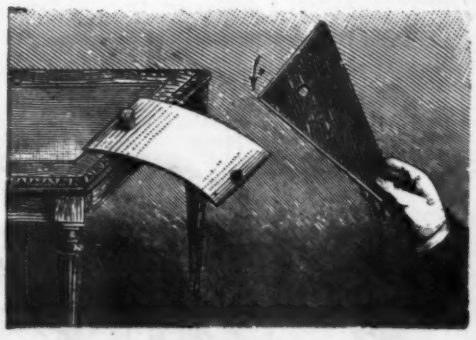


FIG. 1.

way that nearly a half of its length shall extend beyond the table.

In such a position, it would require but the least effort to make the board tilt and cause it to fall. In fact, as the air is capable of introducing itself between the board and the table, no vacuum occurs, and, consequently, a rocking motion may take place without resistance. The same would not occur were the air prevented from passing under the board, and the pressure acting above were thus balanced. Now, nothing is more easily done. It suffices to take an open newspaper and place it in such a way as to cover that part of the board which rests upon the table, as well as quite a wide surface of the table around the board. The paper should adhere as closely as possible to the table.

Things being thus prepared, we shall probably be surprised to see that the strongest man will not be able to make the board tilt by means of a blow of the fist. Further, the harder the blow, the less chance will there be of success. The board will break before it will pivot around the edge of the table.

It will be found, nevertheless, that, if we proceed slowly, the board will tilt with the greatest ease. In these two facts there is only an apparent contradiction. In fact, upon exerting a simple pressure, we allow the air to pass under the board through the interstices left by the journal. With a blow of the fist, on the contrary, the paper, tightly pressed by the atmosphere, closes all the interstices through which the air might pass, so that the effect of the blow is in direct opposition to the enormous pressure of the wind, which it can scarcely overcome.

A very simple calculation will show the stress that would have to be exerted to overcome the resistance of the air. The atmosphere, as well known, exerts a pressure of 15 lb. upon each square inch of the earth's surface. If the part of the board resting upon the table is eight by ten inches, for example, the pressure will be 1,200 lb.

A very simple clock.—When a pendulum is swinging in the air, the amplitude continues decreasing continuously, as the arc of each oscillation is equal to that of the preceding oscillation multiplied by a constant factor. Advantage may be taken of this consideration for the construction of a clock formed simply of a pendulum—a lead ball suspended by a thread. Upon noting upon a dial (formed of a sheet of paper fixed opposite the thread) the extremity of the course of each oscillation (from minute to minute for example), we shall have an apparatus that it will suffice to make oscillate by pulling it back to the last division of the dial in order to make it afterward mark the minutes at the extremity of each oscillation.

It is well to use a pendulum with a double thread, as

FIG. 2.

shown in Fig. 2, so as to keep the plane of oscillation invariable.

The divisions are at the extremity of the dial only, for they become closer and closer in measure as the center is approached, and consequently the precision diminishes. It might, in truth, be possible, by constructing a long and well suspended pendulum, to cause it to operate for several hours, but an ordinary pendulum oscillating but six minutes, for example, has already been used instead of a minute glass for boiling eggs.—*La Science en Famille.*

BATHING AND BOATING ACCIDENTS.*

By IRVING C. ROSSE, A.M., M.D., of Washington, D. C., Professor of Nervous Diseases, Georgetown University.

I AM not sure that I could have selected a more appropriate time and place to bring to the notice of the profession some of the accidents that occur in bathing and boating. Even here in lovely Newport, where I have spent many happy days, sad cases of drowning occur every season, and it is safe to say that most of them arise from inexperience in swimming and are consequently preventable. As a physician and practical athlete, I may show more than ordinary enthusiasm in making a plea for the educational, hygienic, and curative advantages of an exercise that I have practiced at many different places over the world, from the tropics to the Arctic ocean, and in such places as mountain lakes, the mid-Atlantic, and even in a volcanic crater some 2,000 feet deep.

The frequent accounts of drowning that one reads constantly in the daily papers at this season, aside from those occurring in the late floods, instead of dampening, rather rekindle an ardor to which is added a tinge of regret consequent upon the reflection that most of these accidents arise from inability to swim; for with only a moderate knowledge of this easily acquired art, many lives may be saved and much bereavement prevented. Philanthrophic motives, if no other, would, therefore, prompt one to give the matter more than passing notice. In view of the surprising great number of deaths from drowning, it is lamentable in this practical age that the useful art of swimming takes such small part in the training of youth. Young minds are crammed with all sorts of useless information to the neglect of what is essential to the preservation of personal health and the saving of life. Legislators vote large sums of money for doubtful jobs, yet refuse to countenance the establishment of swimming baths in our cities. The police regulations of most of our large towns, conceived in the interests of extreme prudery, virtually tend to make swimming one of the lost arts. Those of the District of Columbia, for instance, were evidently framed in the same spirit of protest which caused a former governor of Maryland to object to midshipmen swimming from a certain wharf in the Naval Academy because the ladies could see them with their opera glasses.

That people do not fully realize the importance of swimming is a trite observation, but a truth none the worse for frequent repetition, and allowing it to lie fallow will never bring about the desired reformation. Long personal experience with swimming so convinces me of its usefulness that, if it came to a choice between knowing the higher mathematics or how to swim, I should choose the latter every time. At many of the larger schools in England lads are obliged to pass in swimming before they are allowed to go out in boats. This rule, established at Eton in 1840, has been effectual there in the prevention of drowning, only one case having occurred since that time, although the swamping of boats has been frequent. A yearly average of 150 boys learn to swim and pass the test. It is, of course, possible to enforce such a rule in schools and among bodies of individuals where discipline obtains,

* Read in the Section of State Medicine at the fortieth annual meeting of the American Medical Association, June, 1889. From the *Journal of the American Medical Association.*

yet this manly and invigorating accomplishment is neglected both in educational establishments and in the army. Swimming is taught at our Naval Academy, but at West Point it is not, and most of the cadets are lamentably deficient in this respect. The statistical exhibits of our late war show the strongest reason why a soldier should know how to swim. The aggregation of killed in action is shown to be 67,058, while there were drowned 106 officers and 4,838 men. The small regular army lost 5 officers and 80 men from this cause; the United States colored troops 6 officers and 289 men; and the volunteers furnished a large contingent, the State of Ohio alone having lost 14 officers and 770 men from drowning. Just think of a number amounting to five regiments perishing from an easily preventable cause—for the majority of these men were drowned in such circumstances as fording a stream, crossing narrow rivers, or by the upsetting of small boats when a few strokes would have sufficed to save life.

But the best swimmers are often drowned, say the cynical wiseacres. True, a good swimmer sometimes meets with that misfortune, but the occurrence is so rare that for that very reason a vivid effect is produced on the imagination and memory of unthinking persons who, accustomed to make *post hoc* conclusions, never for a moment consider the greater number who are saved by knowing how to swim.

Among other prevailing and groundless objections to swimming are the production of colds, the danger of heart failure and the risk of being bitten by sharks. As to colds and the effects of the cold immersion in the water, I should say that the danger therefrom is greatly exaggerated, if my own experience is any guide, for I have never had a cold from swimming in icy water, even under the Arctic circle. On the contrary, one of the severest colds I ever had was contracted in Washington some years since with the thermometer high in the nineties, which necessitated a visit to the seashore, where, after two swims, the cold disappeared as if by magic.

There are, of course, many weak people whose chest organs are in such condition that they should not venture to swim; but I am convinced that the neglect to learn swimming in childhood, and the absence of this eminently hygienic exercise, are responsible for many flabby hearts, weak lungs, and torpid minds.

In addition to being generally tonic and bracing, the effect of swimming considered in itself is to develop the muscular system and to exert a favorable influence on the great bodily functions, as the digestion, nutrition, respiration, circulation and innervation. No other exercise with which I am familiar gets the heart and lungs in better working order, and none is better for getting one in what sporting men call "condition." After two weeks' daily swim in salt water I have run a measured mile on a beach with very little more embarrassment to circulation and respiration than if I had walked the same distance.

Aside from the physical, another advantage of a high order accrues in the way of a happy moral influence. Boxing, sword play, and several other manly pastimes will do much to develop courage, prudence and cleverness; but the cold-blooded quiet and presence of mind which aid us to avoid danger or to conquer it, or to lend ourselves to an act of devotion, are best cultivated by the exercise of swimming. What, for instance, is a more brilliant and commendable act of devotion than that of a dauntless swimmer who, regardless of self, plunges overboard at the risk of his own life to save a fellow being from drowning?

As a curative means, swimming also comes in for praise. In this respect it is superior in many conditions to the so-called "tent cure," to massage, electricity, or drugs, and may be employed with benefit in scrofula, chlorosis, convalescence, insomnia, and many other nervous diseases, as chorea and hysteria. The latter malady especially, I have known to be cured after a course in the swimming baths of Alameda, Cal.; and my experience as a neurologist leads me to recommend swimming as one of the best adjuvants in the treatment of nervous diseases.

The danger to be apprehended from sharks is more a figment of the mind than a reality. I have no personal knowledge of shark bites, although I have done much swimming in such infested places as the Gulf of Mexico, the harbor of Cadiz, the Azore Islands, Bermuda, Tybee, the mid-Atlantic, and other places where these voracious animals are reputed to gobble up such small bait as a man at a single mouthful. For years I have made it a point to question sailors and fishermen in various parts of the world, as to their actual and personal knowledge of shark bites, and though the inquiry has called forth some remarkable fish stories, I have met but two people with any personal knowledge of the matter. Admiral Porter tells me of an instance in which he saw a man attacked; the other person, a pilot at Bermuda, knew of a man that had his hand bitten by a shark just as he was pulling in a hooked fish from the water into his boat. Sharks often collect around the carcass of a whale while it is being "cut in," and men sometimes slip overboard among them, yet, after a long residence in New Bedford, and a somewhat extended experience with the Pacific Arctic whaling fleet, I have never met a whaleman who could tell me of a man that had been bitten. My friend, Mr. Truxton Beale, of Washington, a short time since, when a passenger on the Pacific Mail, showed his unbelief in shark stories by swimming across the shark-infested harbor of Acapulco, although warned by the captain of the ship that he would be eaten up before he got a hundred yards away.

Traditional accounts of the rapacity of sharks are as extravagant as the records of some of the old writers who tell of dead sharks cast upon the shores of the Mediterranean of such size that men walked into the mouth and down the throat in order to inspect the stomach. Even Rondelet, in his History of Fishes speaks of these animals as having swallowed men in entire suits of armor.

Documentary evidence as to shark bites is also very scanty. During the last fifty years, soldiers by the tens of thousands have swum at Fort Monroe, Va., yet there is no record of one having been bitten by a shark, nor have I been able to ascertain that any accident of the kind has occurred at Malta or Gibraltar. There does not appear to be a record of any one ever having been bitten by a shark off the British Isles. I have been unable to ascertain that a single bite of the kind is reported among the medical records of our War or Navy Departments or those of the Marine Hospital. In a book about the West Indies, Mr. Charles Ives says it is singular that so few facts are reported which indicate the danger from Bahama sharks, and that the divers continue to be so numerous and bold. He has heard of but one instance in which a Nassau shark has dined upon a negro, and the report in that case is not well authenticated.

The New York *Herald*, a few years ago, gave an account of a boy who was bitten while in swimming in East River, and afterward died at Bellevue Hospital.

Medical literature has but few reports of shark bites. After ten years' diligent search I have found but seven references, the earliest in the London *Medical Gazette*, 1823, and the latest in the London *Lancet*, 1886. The bites occurred in Australia, South Africa and India. The Hooghley and Ganges Rivers are the worst places in the world for sharks and alligators. A particular kind of shark, the *Carcharras Gangeticus*, which is very fierce and bold, sometimes dashes among the crowds at the bathing ghats, and has been known to bite a boy in two feet of water. All persons bitten at these places generally die from the bite, for the reason that the shark, living on carrion, portions of which stick between the teeth, carries infection to those whom it may afterward bite. The former habit of throwing the dead in the river is supposed to account for the boldness of these particular sharks in attacking the human species.

Even admitting the occasional accident of shark bites, the danger therefrom is almost infinitesimal compared with railway travel or even accidents from horses; and neither this unimportant drawback, nor any other that I have mentioned, should have the least weight in preventing the cultivation and spread of an accomplishment that every one should countenance with a view, not to the renewal of the legendary exploits of Leander and Byron, but as a step in that branch of social evolution which better physical development and improved health tend to promote.

HYPNOTISM IN PARIS.

HYPNOTISM, as one of the forms of mesmerism, after being received for many years with skepticism, and after bringing discredit upon most of its professors and disciples, is now beginning to take its place as a recognized science. It is only fitting that the center of the revival should be in Paris, where there has always been a following of believers in its mysteries and principles.

Its foremost professor now is Dr. Luys, director of the *Revue de Hypnologie*, the organ of the science. The accompanying sketches were taken at the hospital of La Charite, in his consulting room. Dr. Luys is the inventor of a new method of fascination. I have met him, and found him a kindly man, devoted to science, and persuaded that its sole and immediate purpose is to alleviate human suffering. And yet I cannot help thinking that there is something sad, something even wicked about these experiments of his. It is a painful sight to see a number of people reduced to the level of soulless beings, disinherited of will.

This is what Dr. Luys does with his system, and the chief indignity of it is that the process was suggested to him by the one that is used by bird catchers to snare the weakest and most helpless of animals. As a human being, one hardly likes to think that the same lure as that which dazzles the lark can fascinate a human being—that logic, reason, soul, will, can all be subjugated, nay, temporarily annihilated, by the revolutions of a glittering mirror. Yet it is the revolving mirror that Dr. Luys employs—the same as is used in the fields for snaring larks, and the effect produced is an identical one. "The advantage of my system," he says, "is that by means of it one single operator can fascinate at one and the same time an unlimited number of patients, without trouble to himself, and with no loss of force. It has also the advantage of absolute infallibility. I have never known it to fail. Certainly some patients are less susceptible to its effects than others, but none has ever resisted five or six operations. On the other hand, most succumb the very first time, after a lapse of from five to thirty minutes."

HYPNOTISM IN PARIS—PATIENTS HYPNOTIZED BY MEANS OF THE "LARK" MIRROR—EYES OPEN.

HYPNOTISM IN PARIS—PATIENTS HYPNOTIZED BY MEANS OF THE "LARK" MIRROR—EYES SHUT.

The system is as simple as it can be. In the middle of a group of "patients," which may be as large or as small as the operator may determine, is set up on a stand, and on a level with the eyes, a revolving apparatus of bits of colored glass such as is used for snaring larks. The patients are instructed to fix their eyes upon it. "The effect of the revolving glasses," says Dr. Luys, "is exactly the same on men as it is on the birds. On men the rotation of brilliant surfaces produces in predisposed subjects a particular state of the retina, and subsequently of the whole nervous system, accompanied with anæsthesia, immobility of the muscles, 'suggestionability'—in short, the ensemble of phenomena constituting 'fascination.'" It usually takes the full period of half an hour to master an average crowd; some succumb earlier, some later, but the average are mastered in that time. But in the meanwhile what pitiful struggles here and there. This one laughs, he is not going to resign his will to that glittering toy. That one blinks and blinks, and would have the rest believe that it is natural sleep that harasses him. But little by little silence comes on the agitated crowd. One by one they drop off into immobility.

The sleep is different in cases. Some appear as if actually asleep, others have the wide open staring eyes of somnambulists; but in either case the fascination of the subject is complete. He is no longer a human being, merely a muscled machine, the complete serf of the master. Here the lark's mirror and the magnetic pass join hands; the effect produced by the one is the same as that of the other. It is right to say that never on any occasion has Dr. Luys used his power for any but the most benevolent purposes. None of his patients has ever under fascination been required to perform antics of buffoonery for the delectation of visitors. On the other hand, already has this anæsthesia been turned to advantage for painless operations. There has been published in the *Revue de Hypnologie* a long list of cases of successful operations performed on patients under the fascination of the lark mirror.—*London Graphic.*

THE CARBONIZED REFUSE SYSTEM FOR SEWAGE.

WE illustrate the plant which the Rivers Purification Company, limited, Leeds, propose to use for the sewage treatment of towns with a population of 10,000. This process has the advantage of dealing with the dry refuse and dust, as well as the sewage of the town, and by not employing any chemical treatment other than the carbon filters, which are charged with the carbonized dry refuse, appears to possess economical advantages over the older processes. The method of working is as follows:

Dry town refuse is taken up an inclined road, and deposited as required in a carbonizer of the form shown in Fig. 4. The animal and vegetable matter contained in the refuse is reduced to charcoal by a process of slow combustion. The carbonizers are fully charged with the refuse, where it remains until the whole mass is thoroughly charred. The carbonized material is then withdrawn and riddled by means of a circular riddle. Cinders and clinker are laid on one side for use in forming the bottom layers of the filters to be hereafter described. After the filters have been constructed the clinker and cinders will not be required for the filters, but may be utilized for making mortar, road repairing, or may be tipped in any suitable place without any fear of creating a nuisance. The lower layers of the filters may, where convenient, be formed of broken stones or bricks, gravel, and fine pebbles. The finer carbonaceous material, composed principally of charcoal with a small percentage of ash, is used as a filtering material by being placed as an upper layer, 4 in. thick, upon shallow filter beds. The method of forming the filters will be readily understood upon reference to Fig. 5. Fig. 1 shows the plant required for a town of 10,000 population, and Figs. 2 and 3 show longitudinal and cross sections of a filter bed. The method of treating the sewage is briefly thus: It is first passed through a screen which holds back the larger floating substances, after which it is passed through three settling tanks, and thence through three wirework cages filled with cinders of various sizes. The settling tanks and the cinder cages remove the bulk of the solid matter from the sewage. The clarified liquid then passes on to and through the filters previously described, and the effluent, as shown by analysis, is a remarkably good one.

Each filter bed is controlled by a valve connected with a clough, which prevents more than 6 in. of sewage being upon the filter at one time. The sewage is distributed on to the filters by means of branch pipes connected to a central pipe built into the middle wall

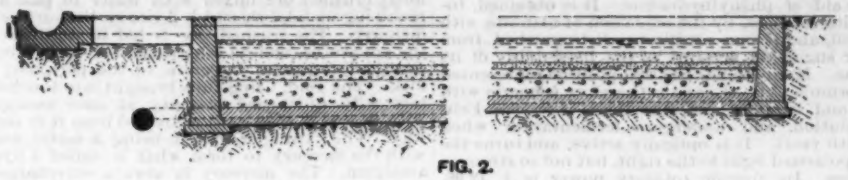


FIG. 2.

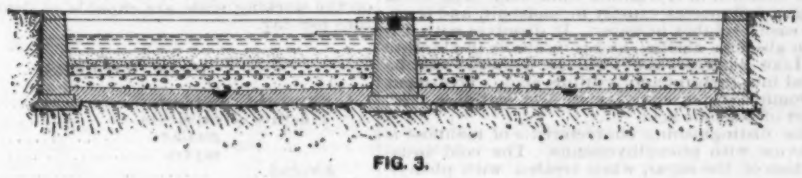


FIG. 3.

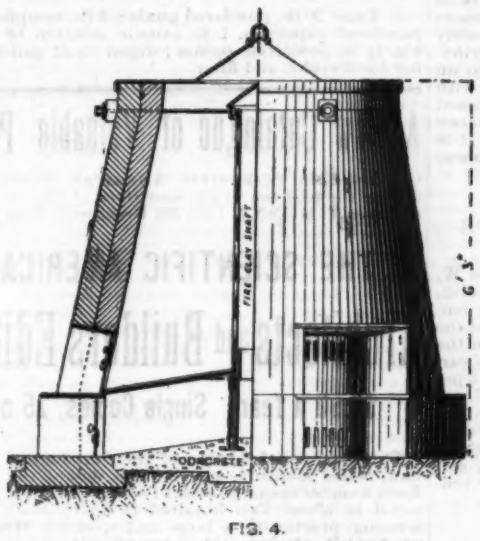


FIG. 4.

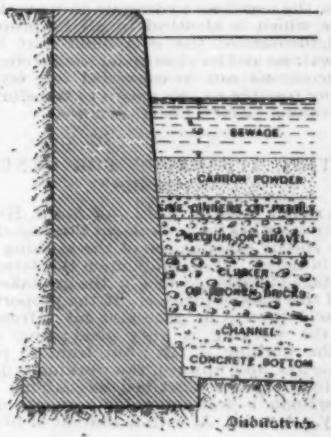


FIG. 5.

THE CARBONIZED REFUSE SYSTEM FOR SEWAGE.

dividing the filter. Under each branch is placed a floating splash board, which prevents the sewage damaging the surface of the filters. After a filter has worked 24 hours, the flow upon that particular filter is diverted to another one at rest. To facilitate the cleansing of the filter put out of work, any sewage remaining upon it is run off by a valve provided for the purpose on to the spare filter above named. As soon as the filter put out of work is sufficiently drained, a thin film which forms on the surface is removed by means of a mechanical contrivance called a scum plow, a little fresh carbon is added, and the filter is again ready for work. A filter of 100 square yards can be cleansed and prepared for work in about ten minutes. The solids deposited in the settling tanks are mixed with the skimmings of the filters, the result being a portable manure, upon which the company have not fixed any great value. It will be noticed that this manure is not mixed with lime or other chemicals, and, therefore, is very different from the sludge obtained in similar processes. If it is of a stable nature, and not prone to undergo any fermentative or putrefying change, it should be a useful nitrogen food for cereals and grass. We should imagine that the filter beds would require to be renewed from time to time with fresh carbonized refuse, in order that the effluent may be of a constant standard of purity. The land required for this process is one acre for each 20,000 population, which is only $\frac{1}{10}$ part of that required for broad irrigation, and $\frac{1}{15}$ part of that necessary for the combined process of chemical precipitation and land filtration. The company guarantee in their contract an effluent the purity of which shall come within the standard laid down in the fifth report of the rivers pollution commissioners.

It is not absolutely necessary that in all cases the refuse be taken to the sewage works. Where the outfall is inconveniently situated with regard to the town the refuse could be carbonized at any suitable point, and the carbon only delivered to the company at the purification works. The refuse, for instance, might in some cases be carbonized at the gas works. In towns where destructors are already in existence they, at no great cost, might be converted into carbonizers.—*Industries.*

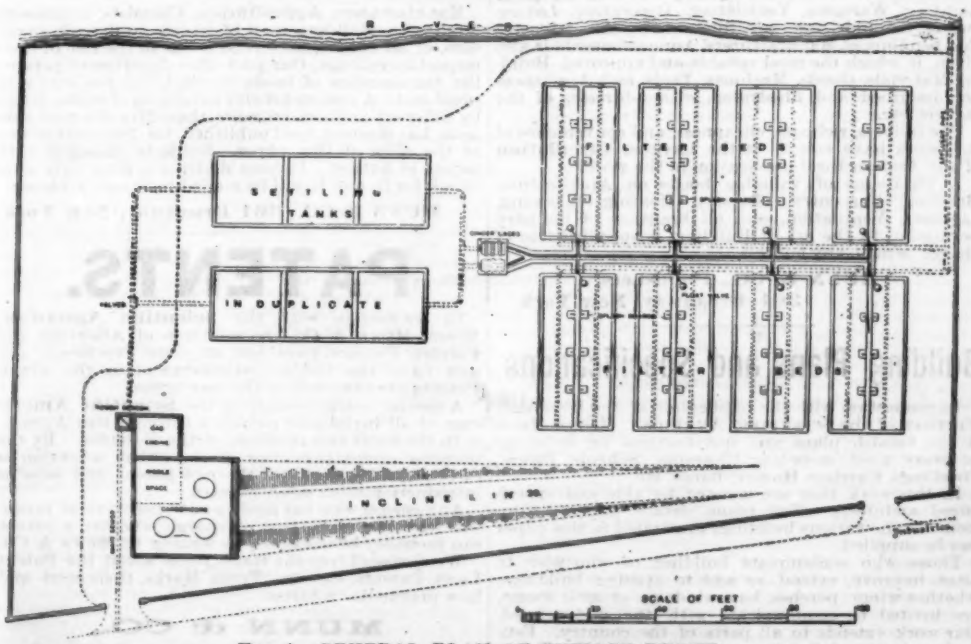


FIG. 1.—GENERAL PLAN OF SEWAGE PLANT.

THE CARBONIZED REFUSE SYSTEM FOR SEWAGE.

RECENT SYNTHETICAL EXPERIMENTS IN THE SUGAR SERIES.

PROFESSOR EMIL FISCHER'S researches on the sugars of the glucose group have been remarkably successful, and recently he has effected the synthesis of both dextrose and levulose. A year ago, in this *Journal*,* the experiments were described by means of which he had succeeded in preparing a new synthetical sugar, which he called acrose, and which was found to be an isomer of dextrose and levulose. Acrose possesses all the general properties of dextrose and levulose, and only differs from these natural sugars in being optically inactive. Fischer has now succeeded in determining the constitution of acrose, and in his recent papers† he has shown that it is the inactive modification of levulose. It bears the same relation to ordinary levulose that racemic acid bears to ordinary tartaric acid; and just as racemic acid can be split into dextro and levo tartaric acids, so from acrose ordinary levulose and a new levulose, having an equal but opposite rotary power, can be obtained.

The obstacles that are encountered in this kind of work are very great, and one can gain some idea of the difficulty of determining the constitution of a sugar by remembering that, according to the Le Bel-Van't Hoff hypothesis,‡ a compound with four asymmetric carbon atoms like dextrose can exist in sixteen stereometric forms. Nevertheless, Fischer has not only determined the constitution of acrose and effected the synthesis of levulose, but he has also discovered the inactive and the levo modifications of mannite and of the new sugar mannose. He was shown that mannose and dextrose have the same constitution and that one may be converted into the other. He has further prepared all these substances synthetically, and what is also of very great importance, he has developed and perfected the methods of transforming the sugars and their derivatives into one another to such an extent that the synthesis of the remaining members of the glucose group

* This *Journal*, 11, 277.
† Ber. d. chem. Ges., 23, 372, 376.
‡ Van't Hoff. Dix années dans l'histoire d'une theorie, p. 54.

will probably be effected in the near future. In fact, so great are the additions to our knowledge resulting from these researches that Fischer's work may well be said to mark the beginning of a new epoch in the history of the carbohydrates.

Mannose.

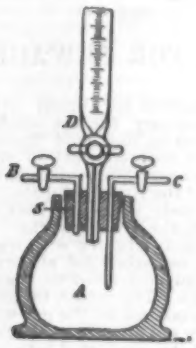
This new sugar was discovered by Fischer * in studying the oxidation products of the polyacid alcohols with the aid of phenylhydrazine. It is obtained, together with levulose, by the oxidation of mannite with nitric acid, and it can readily be distinguished from the other sugars on account of the insolubility of its hydrazone. Mannose has the composition represented by the formula $C_6H_{12}O_6$, and is therefore isomeric with dextrose and levulose, and, like these, it reduces Fehling's solution, and undergoes fermentation when mixed with yeast. It is optically active, and turns the plane of polarized light to the right, but not so strongly as dextrose. Its specific rotatory power is + 12·96, that of dextrose being + 58·7. Reduction with sodium amalgam converts it into mannite. Mannose has not yet been obtained in crystalline condition. The white solid sugar deliquesces rapidly in moist air, and is extremely easily soluble in water. It dissolves with difficulty in absolute alcohol, and is insoluble in absolute ether. Like dextrose and levulose, mannose can be converted into furfurol and levulinic acid. Treatment with bromine water converts it into mannose acid, an isomer of gluconic acid.

But the distinguishing characteristic of mannose is its behavior with phenylhydrazine. The cold aqueous solution of the sugar, when treated with phenylhydrazine, gives at once a crystalline precipitate of mannose phenylhydrazone, whereas the hydrazones of dextrose and levulose and the other sugars are readily soluble in water. When heated with more phenylhydrazine, the mannose hydrazone is converted into an osazone, which is identical in all its properties with phenylglucosazone, the compound that is obtained from dextrose and levulose under similar circumstances. As glucosazone can be converted into levulose, it is therefore possible by this means to transform mannose into levulose.—*Amer. Chem. Journal.*

A TEST APPARATUS FOR GENERATOR GASES.

IN a recent issue of *Stahl und Eisen*, Herr Von W. Thorner describes the instrument illustrated herewith, for the speedy examination of the working of gas generator furnaces. It depends upon the detection of the percentage of carbonic acid in the gas taken from the flues of this class of furnace. If the proportion of carbonic acid present in generator gas is from 2 to 3 per cent., the working is very good; from 5 to 6 per cent. the working is fair; but from 10 per cent. of carbonic gas, and upward, the working is defective.

The instrument is described as enabling any intelligent foreman to test generator furnaces quickly and reliably. A vessel, A, with a content of 100 cubic centimeters at 17° C., is fitted with a ground stopper, S, carrying inlet and outlet tubes with cocks, B and C, as well as a burette, E, entering the stopper by a capillary stem as shown. This burette may contain 15 or 16 cubic centimeters of caustic potash in a 20 per cent. solution, the level of which is indicated by the graduations of the tube. The method of operating the instrument is almost obvious. A current of the gas to be tested is aspirated through the vessel for about two minutes, until the atmospheric air is displaced, and the cocks of the gas tubes are closed after the contained gas has been brought to the normal atmospheric pressure. The cock of the burette is then opened, and the solution of potash absorbs the contained carbonic acid; the quantity required being indicated by the burette. From this the proportion of carbonic acid in the generator gas may be directly seen. The apparatus, which is manufactured by Messrs. Fischer and Roewer, of Stutzerbach (Thuringen), may also be used for the examination of chimney gases.



HYDROGEN AMALGAM.

RATHER more than two years since we described a very satisfactory process of gold amalgamation, the invention of Mr. B. C. Molloy, M.P., which we then saw in operation upon a small scale. The adoption of this process at some gold mines in New Zealand led to the discovery in practical working of a few minor defects in some of the details. These defects having been remedied, and the process having been adopted at several gold mines, milling and amalgamating works have been fitted up at No. 10 Charles Street, Blackfriars' Road, London, by the Economic Gold Extraction Company.

These works were recently inspected in operation by a number of gentlemen interested in gold mining. The Molloy system recognizes and successfully deals with the fact that, first, what is known as float gold frequently gets away without becoming amalgamated with the mercury, and that, secondly, in the case of refractory ores amalgamation is rendered impossible by reason of the mercury sickening or becoming sluggish, owing to the presence of sulphides and other deleterious ingredients which act prejudicially upon the mercury. These two difficulties are overcome by the new process by causing every particle of the ore to be brought into absolute mechanical contact with the mercury, and by causing a current of electricity to act on a small quantity of a permanent salt solution, by which means hydrogen is generated on the mercury itself. The mechanical difficulty is met by causing the finely crushed ore mixed with water to pass under a revolving metal disk which floats on the surface of the mercury. The crushed ore is fed in at the center of the apparatus, and by centrifugal action is forced and squeezed out, grain by grain, to the periphery of the disk. The gold, being thus brought into touching contact with quickened mercury, at once amalgamates with it, and is afterward recovered from it in the usual way. The hydrogen formed, being a metal, combines with the mercury to form what is called a hydrogen amalgam. The mercury is always overcharged with hydrogen, and the presence of the latter prevents the oxidation or sickening of the former. The works which have been put up for the purpose of testing ores on the working scale are capable of dealing with ten tons per day.

* Ber. d. chem. Ges., 21, 1806; 22, 365.

PAIN KILLERS.

1. SPIRIT of camphor .....2 oz.
Tincture of capsicum.....1 "
" guaiac ..... ½ "
" myrrh ..... ½ "
Alcohol.....4 "

2. Take 20 lb. powdered guaiac, 2 lb. camphor, 6 lb. powdered capsicum, 1 lb. caustic solution of ammonia, ¼ lb. powdered opium; digest in 32 gallons alcohol for 2 weeks, and filter.

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